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Biomarker-Performance Associations During Nutritional and Exercise Intervention in Air Force Personnel

Jennifer Jurcsisn
Wright State University

BIOMARKER-PERFORMANCE ASSOCIATIONS DURING NUTRITIONAL AND EXERCISE INTERVENTION IN AIR FORCE PERSONNEL

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy

By

JENNIFER JURCSISN
M.S., Wright State University, 2014
B.S., Wright State University, 2011

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I HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER MY SUPERVISION BY Jennifer Jurcsisn ENTITLED "Biomarker-performance associations during nutritional and exercise intervention in air force personnel" BE ACCEPTED IN PARTIAL FULFILMENT OF THE DEGREE OF Doctor of Philosophy.

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Erica M. Johnson, Ph.D.
Co-Director

_____

Christopher N. Wyatt, Ph.D.
Co-Director

_____

Mill W. Miller, Ph.D.
Director, Biomedical Sciences
Ph.D. Program

_____

Barry Milligan, Ph.D.
Interim Dean of the Graduate School

Committee on Final Examination

_____
Lynn Hartzler, Ph.D.

_____
David R. Cool, Ph.D.

_____
Assaf Harel, Ph.D.

ABSTRACT

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This study evaluated the combined effects of an exercise intervention and nutritional supplement on biomarkers of stress and resilience, and the relationships of those markers with physical and cognitive performance. 130 healthy Active-Duty Air Force (AF) personnel were recruited to participate in a double-blind, placebo controlled 12-week exercise and nutritional intervention. Serum was collected at basal and high stress conditions pre- and post-intervention to track the following biomarkers: cortisol, dehydroepiandrosterone-sulfate (DHEA-S), norepinephrine (NE), neuropeptide Y (NPY), and serotonin. The exercise intervention significantly attenuated the cortisol response and peak stress cortisol levels. The nutritional intervention decreased peak stress NE. The selected biomarkers were not universally correlated with performance measures. NPY, NE, and cortisol levels showed strong relationships with several dimensions of physical performance during stress, though resting NPY and NE levels did not. Few correlations were observed between biomarkers and cognitive performance. We conclude that these interventions had mixed and modest effects on biomarker levels of stress and resilience and that their relationships with performance is dependent on task type and stress

condition. For future research, we recommend measuring additional biomarkers and tailoring interventions to the individual subject for greater efficacy.

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BACKGROUND

Air Force Readiness

The Air Force (AF) places high demand on Airmen in their daily duties, both physically and cognitively. To ensure mission success, Airmen are expected to perform at their peak regardless of adverse working conditions such as physical exhaustion, heat stress, sleep deprivation, dehydration, and inadequate nutrition. Acquiring and sustaining such performance requires these Airmen to regularly engage in rigorous exercise training and job-skills education. However, as the wide-range of AF operations become more complex, competitive, and technologically advanced, the AF must continuously develop innovative methods to get the most out of the everyday training and maximize Airmen readiness. Biomarkers may have the capacity to serve as a tool with which to develop these approaches. With the understanding of biomarkers and their associations with performance, fitness, and nutrition, Airmen's physiology may be better monitored, analyzed, and appropriately adjusted. Providing the tools and interventions to optimize Airmen performance will lead to improved work quality and decision-making. This study aims to lay the groundwork on which these physiological monitoring, assessment, and enhancement strategies may be based.

Nutritional Supplementation

It is perhaps unsurprising that the AF is interested in leveraging nutrition as a means to improve performance. Potentially due to the demanding, high-stress nature of military work, service members already report taking more nutritional supplements for performance enhancement than their civilian counterparts. This has incited research which suggests that targeted nutritional supplements and specialized exercise training regimens can, in fact, enhance physical and cognitive performance in Airmen (Bovill, 2003; Lieberman, 2010; Lennemann, 2013). This is consistent with clinical studies which report that over-the-counter (OTC) supplements such as caffeine and tyrosine can improve cognitive faculties such as vigilance and stress resilience (Lieberman, 2003). Likewise, protein-based supplements can improve physical attributes such as post-exercise muscle recovery (Flakoll, 2004; Kraemer, 2007).

With the ever-increasing demand the AF places on soldiers and the growing body of evidence that performance may be enhanced with relatively simple, non-invasive measures, it stands to reason that the AF must develop and evaluate targeted nutrition programs for the benefit of its workers and the military at large.

Our collaborators at Abbott Nutrition (makers of Ensure®, Pedialyte®, EAS®, and Myoplex®) have developed a multi-purpose liquid nutritional supplement to promote cognitive function and improve muscle recovery. This supplement was designed specifically to meet the complex performance needs of Airmen, many of whom work jobs that are physically and cognitively challenging (e.g., field medic, pilot, combat controller, flight line mechanic, etc.). This supplement was created by assembling previously FDA-

approved nutrient formulas that are available in some of Abbott's existing OTC products. A primary goal of the current research was to test the effectiveness of this supplement in its target population.

Exercise Intervention

Nutritional supplements are typically used in conjunction with exercise programs to further boost performance gains. While other branches of the military endorse and utilize formal exercise interventions for their soldiers (e.g., the Army's Physical Readiness Training, or the Navy Operational Fitness and Fueling System), the AF has not yet followed suit.

These military-approved exercise interventions are centered on the concept of functional fitness, which is the idea of incorporating occupationally relevant exercise movements to optimize job-specific performance (Abt et al., 2010). Unlike traditional exercises which emphasize strengthening single muscle groups (e.g. bicep curls), functional fitness uses multi-planar movements that integrate balance and coordination along with strength. Some exercises are designed to simulate actual movement patterns necessary in a specific field of work, but done so in a controlled setting where soldiers are taught proper form and execution (Heinrich, Spencer, Fehl, & Carolos-Poston, 2012). Functional fitness also adopts contemporary aerobic exercises such as high-intensity interval training (HIIT), which has shown to be more effective in improving cardiovascular fitness than conventional steady-state running (Heinrich et al., 2012). This suggests that the principles of functional fitness should be an essential part of the

foundation on which future, AF-specific exercise programs should be based, and therefore were used to develop the novel exercise intervention in this study.

Biomarkers of stress and performance

Biomarkers have the potential to provide a connection between objective measures of physiology and performance. These markers may then become targets appropriate for physiological monitoring, stress mitigation, and performance enhancement.

Stress is a key aspect of physiology known to affect human performance (Kirschbaum, 1996; Thomas, 2014). While acute stress may prove beneficial to performance (Greiwe, 1999; Zouhal, 2008), this benefit is temporary. Chronic and prolonged stressors result in performance detriment (Sapolsky, 2000; Bremner, 2006). Active duty military, especially members that have been deployed, face increased levels of stress that put them at risk for impaired performance (Booth-Kewley, 2010).

As mentioned previously, nutritional supplements and exercise training regimens have the potential to improve cognitive and physical performance. Each of these types of interventions can also change a person's biomarker profile (Chatard, 2002; Agha-Alinejad, 2013; Kohanpour, 2013; Noreen, 2010; Aizawa, 2003, Markus, 2002). However, these associated changes in performance and physiology are not well-defined, particularly in the AF population. The better understood these connections are, the better they may be used for targets of performance monitoring and enhancement. This study

aims to clearly link aspects of physical and cognitive performance with empirical measures of blood-based biomarkers of stress and resilience.

Due to the association of stress and performance, well-established biomarkers of stress will be measured over the course of these intervention programs. Perhaps equally important are measures of stress resilience markers, which have been shown to positively correlate with performance. Lastly, measures of neurotransmitters and cognitive signals have been linked with performance as well. For these reasons, the primary biomarkers chosen for examination in this study are: cortisol, dehydroepiandrosterone-sulfate (DHEA-S), norepinephrine (NE), neuropeptide-Y (NPY), and serotonin.

Cortisol

The glucocorticoid cortisol is a steroid hormone secreted by the adrenal cortex as the end-product of the Hypothalamic-Pituitary-Adrenal (HPA) Axis activation cascade in response to stress (Mason, 1968). Cortisol binds to glucocorticoid receptors (GRs) in the cytoplasm which then shuttle as a complex into the nucleus (Galigniana, 1998) to activate or repress transcription of genes that regulate metabolism (Newton, 2000). GRs are found ubiquitously throughout the body, resulting in pleiotropic effects upon cortisol release (Anacker, 2011). Cortisol primarily functions to prepare the body for future stress events via catabolism of stored energy resources. Cortisol increases in blood glucose concentrations by promoting glycogenolysis, lipolysis, and gluconeogenesis. Conversely, cortisol inhibits anabolic processes such as muscle growth and fat storage. Cortisol also functions to decrease inflammation and suppress the immune system by reducing

production of eicosanoids (prostaglandins) and inflammatory interleukins (Reichardt, 2001).

Cortisol exhibits diurnal fluctuation in humans, peaking in the hour after waking and decreasing throughout the day. Lower resting cortisol levels are associated with lower levels of stress. Exposure to a stress challenge, such as strenuous exercise (Davies, 1973; Daly, 2005), public speaking (Bassett, 1987), or an academic exam (Maes, 1998) causes cortisol levels to increase significantly from baseline and peak approximately 20 minutes after the event. The severity of the stress and the level of an individual's stress resiliency will affect the extent of this increase (Morgan, 2002; Rimmele, et al. 2007).

Cortisol is lipid soluble and readily crosses the blood-brain barrier (BBB). Very high cortisol levels released in response to stress are associated with performance detriment (Kirschbaum, 1996; Thomas, 2014). Similarly, studies show that chronic exposure to high cortisol levels may induce hippocampal atrophy (Sapolsky, 2000) and impair memory functioning (Bremner, 2006).

Studies have shown that exercise training programs can reduce baseline cortisol levels (Staron, 1994; Kraemer, 1999; Chatard, 2002; Agha-Alinejad, 2013; Kohanpour, 2013). Supplementation with fish oil has been shown to reduce salivary cortisol and total body fat mass (Noreen, 2010) as well as reducing cortisol levels in response to a mental stress test (Delarue, 2003).

Due to its involvement in stress, performance, exercise, and nutrition, cortisol serves as a primary biomarker of interest in this study.

Dehydroepiandrosterone-sulfate (DHEA-S)

Like cortisol, dehydroepiandrosterone (DHEA) is a steroid hormone released from the adrenal cortex as a result of HPA axis activation. DHEA is the most abundant hormone in humans (Maninger, 2009). Levels of DHEA peak in early adulthood and gradually decline with age (Orentreich, 1984). DHEA serves as a precursor molecule for testosterone and estrogen biosynthesis, but also applies its own effects as a neurosteroid (Starka, 2015). DHEA has no unique receptor, but binds to and activates N-methyl-D-aspartate (NMDA) receptors, inhibits gamma-Aminobutyric acid $(GABA)_A$, D2 dopamine, and glycine receptors, contributing to overall excitatory activity (Perez-Neri, 2008). DHEA exerts protective effects in the brain (Kaasik, 2001) and has been shown to induce neurogenesis in the rat hippocampus (Karishma, 2002).

DHEA has a half-life of approximately 20 minutes. DHEA can be sulfated only in certain tissues (brain, lungs, liver, adrenals, kidneys, and intestines), but can be de-sulfated in all tissues. The sulfated form of DHEA (DHEA-S) binds with greater affinity than DHEA to the carrier protein albumin. This binding slows its metabolic clearance, making DHEA-S levels relatively stable, lasting approximately 10 hours (Kamin, 2016). As a result, DHEA-S does not exhibit diurnal fluctuation (Starka, 2015). Circulating levels of DHEA-S are considered the body's "DHEA reservoir" and changes in these levels are indicative of long term effects.

Both DHEA and DHEA-S levels rise in response to a stressor (Taylor, 2012), however, these increases are associated with *resilience* to stress (Morgan, 2009). Petros 2013 showed that salivary DHEA-S is highly correlated to positive aspects of

psychological health/resilience, whereas lower levels of DHEA-S have been associated with increased perceived stress (Lennartsson, 2013). In rats, DHEA has been shown to inhibit cortisone reductase, the enzyme which reduces cortisone to cortisol prior to its release (Tagawa, 2011). Due to these observations, DHEA and DHEA-S are considered to function as a counter-balance to cortisol.

Aizawa, 2003 showed that resistance exercise training can increase DHEA-S levels. Nutrition may also impact levels of DHEA and DHEA-S. Calorie restriction paradigms are well-known to increase longevity and have been reported to slow the age-related decline of serum DHEA-S in rhesus monkeys (Lane, 1997).

DHEA-S levels may also be predictive of performance. Morgan, 2009 showed that higher baseline DHEA and DHEA-S levels sampled pre-task were positively correlated to underwater navigation scores in active duty military subjects.

Norepinephrine (NE)

Immediate responses to a stressor include autonomic nervous system (ANS) activation – the "fight-or-flight" response. ANS activation stimulates catecholamine (epinephrine [Epi], norepinephrine [NE], and dopamine) release from sympathetic fibers and the adrenal medulla. Epi binds to beta-adrenergic receptors in heart to increase heart rate. NE binds primarily to alpha adrenergic receptors. In the lungs and bronchi, binding results in airway dilation and increased oxygen uptake. In the trunk, binding results in splanchnic arterial vasoconstriction to decrease local circulation and increase systemic

arterial pressure and venous return. In the liver, binding results in glycogenolysis and increased blood glucose (for review, see Garcia-Sainz, 1995).

Given that Epi and NE are involved in aspects of cardiovascular regulation such as control of breathing (Orem and Kubin, 2000) and glycogenolysis (Kreisman, 2001), it has been suggested that higher *peak* levels may confer physical performance benefit – the "sports adrenal medulla" theory (Kjær et al, 1986). While Greiwe, 1999 supported this theory by showing increased catecholamine release in trained versus untrained individuals, other studies suggest exercise training causes a *decrease* in exercise-induced catecholamine release post training intervention, despite increases in VO_2 Max scores (Friedlander et al., 1998, Winder et al., 1978, Winder et al., 1979). The effect of exercise training on resting catecholamine levels is also mixed (Zouhal, 2008).

NE is also released centrally by the locus coeruleus to targets spanning the entire frontal lobe. It is involved in the control of attention and working memory (Clark, 1989; Smith, 1992; Coull, 1995). NE is related to cognitive performance, but these measures are dependent on an individual's baseline arousal levels (Coull, 1999). Increases benefit lower arousal and impair higher arousal. Wang, 2013 bolstered these data by showing increases in NE improved cognitive performance, though *excessive* NE increases impaired performance.

Of the catecholamines, NE was chosen for examination given its established association with both physical and cognitive performance.

Neuropeptide-Y (NPY)

NPY is a 36 amino-acid neuropeptide. It is co-localized in the adrenal medulla and sympathetic fibers with NE and similarly released in response to ANS activation (Schutz, 1998). It is also produced and released throughout the central nervous system (CNS). No primary source of central NPY is known, but it is highly expressed in the hypothalamus, amygdala, hippocampus, septum, and neocortex (Michel, et. al 1998; Kask, 2002). NPY binds mainly to the Y family of receptors (Y1, 2, 4, 5, and 6) which are inhibitory G-coupled receptors. NPY is widely involved in energy homeostasis, promoting feeding behavior and fat storage (Loh, 2015). Centrally, NPY acts a vasodilator and induces anxiolytic effects in animal models (Heilig, 1989; Heilig, 1992; Sajdyk, 2004). Peripherally, NPY regulates blood pressure by acting directly as a vasoconstrictor and by modulating catecholamine release (Westfall, 2004; Holwerda, 2015). Further studies associate NPY with stress resilience in humans (Rassmusen, 2000; Morgan, 2003). Notably, NPY does not cross the BBB. Plasma NPY levels are not correlated with cerebrospinal fluid (CSF) NPY levels and do not exhibit diurnal fluctuation (Baker, 2013).

Though NPY does not cross the BBB, peripheral levels have been correlated with performance under stress. Morgan, 2000 showed that US Army soldiers released NPY in conjunction with cortisol and NE, but those who had higher levels of NPY release had better performance scores under simulated enemy capture-and-interrogation and fewer symptoms of dissociation, a product of high stress. This study was replicated in US Navy personnel and found concurring results (Morgan 2002). Lieberman, 2016 also showed

that in US Army soldiers, performance under extreme stress was positively associated with higher levels of NPY.

Serotonin

Serotonin (5-hydroxytryptamine or 5-HT) is a monoamine converted from the amino-acid L-tryptophan by the enzyme tryptophan hydroxylase. It is released centrally by the Raphe Nuclei, hypothalamus, and cerebellum (Simansky, 1996). Peripherally, it is released by the enterochromaffin cells of the gut endothelium and stored in circulating platelets (Erspamer, 1954). Serotonin binds to the 5-HT family of receptors which have a wide range of function. Most are G-coupled receptors - one is a ligand-gated ion channel - and most are excitatory. Serotonin does not cross the BBB but its precursor L-tryptophan does (Birdsall, 1998). Serotonin is involved in mood, memory, the sleep/wake cycle, appetite regulation, gut motility, energy homeostasis, control of breathing, and vascular tone (Rapport, 1948; Young, 1985; Altman, 1988; Risch, 1992; Bach, 1993; Jouvet, 1999; Kereveur, 2000).

Stress increases serotonergic activity in the brain (Joseph, 1983). Prolonged stress may exhaust serotonin availability over time, resulting in worsened cognitive performance as resources decline (Markus 1998; Markus, 1999). While serotonin cannot cross the BBB, AFRL investigators have argued that peripheral serotonin may be associated with cognitive performance. Data from Shia et al. 2015 shows that subjects performing a treadmill task who displayed higher levels of serotonin pre- versus post-task showed decreased performance, while subjects who displayed levels of serotonin that

increased pre- to post-task showed sustained performance (Shia et al., 2015). This evidence supports the idea that serotonin may be involved in central resource availability.

Exercise training has been shown to increase serotonin levels in the rat brain, providing a potential mechanistic cause for the well-known antidepressant effects of exercise (Dey, 1992). Nutritional deficits that cause lowered tryptophan levels result in depressed mood (Young, 1985). Supplementation with alpha-lactalbumin, a precursor of serotonin, has been shown to increase cognitive performance in subjects particularly vulnerable to stress (Markus, 2002). Though there is less evidence for serotonin's associations with performance compared to the previous biomarkers, we propose that it warrants further investigation.

SPECIFIC AIMS

This study aims to evaluate the effects of a unique nutritional supplement combined with requisite physical training on biomarkers of stress, resilience, and vigilance. Biomarker levels will be associated with cognitive and physical performance measures. Understanding these relationships will help identify target biomarkers for the development of future interventions aimed at cognitive and physical performance enhancement. We hypothesize that the nutritional supplement and physical training interventions will decrease biomarkers associated with stress and/or increase markers of resilience, arousal, and vigilance, and these changes will be linked with performance improvement.

Aim 1a:

Assess the changes in biomarkers of stress, resilience, and vigilance over the course of the **exercise** intervention. We hypothesize that both groups will exhibit lower stress markers and/or higher resilience and vigilance marker levels post-intervention compared to pre-intervention.

Aim 1b:

Assess the changes in biomarkers of stress, resilience, and vigilance over the course of the **nutritional** intervention. We hypothesize that the experimental supplement

group will exhibit lower stress markers and/or higher resilience and vigilance markers pre-to post-intervention as compared to control.

Aim 2:

Establish relationships between cognitive and physical performance and peripheral blood biomarkers of stress, resilience, arousal, and vigilance. We hypothesize that higher performance will be associated with lower stress and/or higher resilience and vigilance biomarker levels.

METHODS

Experimental Design and Sample Size

A 2x1, double-blind, placebo-controlled design was implemented. Participants were assigned to one of two groups – Experimental or Placebo – and underwent the same exercise training intervention. Due to space and personnel limitations, the study was divided into six cohorts of approximately 25 participants per cohort. Participants were over-recruited (max 35 per cohort) to mitigate the effects of attrition. Within each cohort, participants received the same nutritional supplement (experimental or placebo) and the groups were seasonally balanced (see Table 1).

Table 1. Study design. The two groups were divided into six cohorts and seasonally balanced. Both subjects and experimenters were blind to this design.

Season	Year 1	Year 2
Winter (Jan-Apr)	Cohort 1 (experimental)	Cohort 4 (placebo)
Summer (May-Aug)	Cohort 2 (placebo)	Cohort 5 (experimental)
Fall (Sep-Dec)	Cohort 3 (experimental)	Cohort 6 (placebo)

Participants

Active duty Air Force men and women between the ages of 18-45 were recruited. To determine eligibility, the demographics and health screening questionnaire (See Surveys/Questionnaires) were reviewed by the medical monitor prior to any participant taking part in experimental procedures. Airmen were excluded from participating in this study if:

- They were not active duty
- They were unable/unwilling to commit to participating in this study for 14 consecutive weeks
- They were younger than 18, or older than 45, years of age
- They were on a medical or pregnancy profile
- They were taking prescribed blood pressure medication
- They were unwilling to stop the use of certain herbal dietary supplements, performance supplements, or any other substance that contains ingredients that could affect cardiovascular response with exercise.
- They were suffering from a musculoskeletal injury that would limit their ability to engage in heavy resistance and/or aerobic exercise.
- They were suffering from cardiovascular or respiratory disease that would limit their ability to engage in heavy resistance and/or aerobic exercise.

Duration

Data collection lasted two years. The total duration of participation for each subject in this study was 14 weeks. The testing and training schedule is provided in Figure 1. In this schedule, weeks 1 and 14 were allocated to baseline and post-test performance assessments, and weeks 2 through 13 were allocated to participation in the exercise training and nutritional interventions

Figure 1. Exercise intervention testing and training schedule.

Individual Participant Testing & Training Schedule

Testing

Week 1 – Baseline Testing		
Mon (2 hrs.)	Wed (2 hrs.)	Fri (2 hrs.)
Blood Draw/Physical Test Battery (Part 1)	Physical Test Battery (Part 2)	Cog Test/VO_2max/Blood Draws

Exercise Intervention

Weeks 2, 6, & 10				
Mon (1 hr.)	Tues (1 hr.)	Wed (1 hr.)	Thurs. (1 hr.)	Fri (1 hr.)
Total Body Resistance Circuit 1	Active Recovery & Light Cardio 1	Total Body Resistance Circuit 2	Active Recovery & Light Cardio 2	Intense Cardio Circuit 1 (Bike, Run, Elliptical)

Weeks 3, 7 , & 11				
Mon (1 hr.)	Tues (1 hr.)	Wed (1 hr.)	Thurs. (1 hr.)	Fri (1 hr.)
Total Body Resistance Circuit 3	Active Recovery & Light Cardio 3	Total Body Resistance Circuit 4	Active Recovery & Light Cardio 4	Intense Cardio Circuit 2 (Bike, Run, Elliptical)

Weeks 4, 8, & 12				
Mon (1 hr.)	Tues (1 hr.)	Wed (1 hr.)	Thurs. (1 hr.)	Fri (1 hr.)
Total Body Resistance Circuit 5	Active Recovery & Light Cardio 5	Total Body Resistance Circuit 6	Active Recovery & Light Cardio 6	Intense Cardio Circuit 3 (Bike, Run, Elliptical)

Weeks 5, 9 & 13				
Mon (1 hr.)	Tues (1 hr.)	Wed (1 hr.)	Thurs. (1 hr.)	Fri (1 hr.)
Total Body Resistance Circuit 7	Active Recovery & Light Cardio 7	Total Body Resistance Circuit 8	Active Recovery & Light Cardio 8	Intense Cardio Circuit 4 (Bike, Run, Elliptical)

Testing

Week 14 – Post-Test		
Mon (2 hrs.)	Wed (1.5 hrs.)	Fri (1.5 hrs.)
Blood Draw/Physical Test Battery (Part 1)	Physical Test Battery (Part 2)	Cog Test/VO_2max/Blood Draws

Nutritional Supplements

Supplement Description

Abbott Nutrition prepared two liquid nutritional supplements for examination in this study. The first was the experimental supplement, from here on referred to as the high nutrient supplement. This supplement was a tailored combination of active nutrients independently shown to be effective for improving cognitive function (e.g., docosahexaenoic acid [DHA] and lutein), and promoting muscle recovery (e.g., calcium hydroxy-methylbutyrate [Ca-HMB] and protein). The high nutrient supplement had a caloric content of no more than 270 calories (Cal) per 8 oz. serving. The second supplement was a placebo, from here on referred to as the low nutrient supplement. This supplement was comprised of marginal amounts of protein, fat, carbohydrates, and minerals in order to provide some of the basic nutrition necessary for exercise. The low nutrient supplement had a caloric content of no more than 110 Cal per 8 oz. serving.

Supplement Dosage Schedule

Throughout the exercise intervention (Weeks 2 to 13), participants ingested two 8 oz. servings of either the high or low nutrient supplement (dependent upon group assignment) per day. During the work week (Monday through Friday), ingestion of each serving was be supervised by research staff. It was recommended that ingestion occur a few minutes prior to and immediately following each exercise session, but some participants chose to ingest their servings all prior to exercise, all post exercise, or as a meal replacement earlier in the day (also supervised). On the weekends (Saturday and

Sunday), research staff provided participants with a total of 4 servings to take home, and asked that participants take the supplement along with breakfast and lunch (See Table 2 for a dosage schedule). In order to confirm compliance with weekend ingestion, participants were required to return the empty bottles to the researchers on each following Monday.

Table 2. Weekly nutritional supplement dosage schedule for all participants.

	Weekly Nutritional Supplement Dosage Schedule						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Supervised Ingestion by Research Staff	Yes	Yes	Yes	Yes	Yes	No	No
Ingestion Timing	8 oz. prior to exercise; 8 oz. post-exercise	8 oz. prior to exercise; 8 oz. post-exercise	8 oz. prior to exercise; 8 oz. post-exercise	8 oz. prior to exercise; 8 oz. post-exercise	8 oz. prior to exercise; 8 oz. post-exercise	8 oz. with breakfast; 8 oz. with lunch	8 oz. with breakfast; 8 oz. with lunch

Biomarkers

Blood Sample Collection

To determine the changes in biomarker levels, peripheral blood samples were collected throughout the course of this study. Samples were collected by AFRL medical technicians and certified phlebotomists via antecubital venipuncture. To appropriately obtain and preserve the biomarkers in each sample, serum collection tubes (red-top) and plasma collection tubes with K2 EDTA (purple-top) were used (BD Vacutainer). Immediately following each draw, samples will be allowed to clot for 30-60 minutes at room temperature. Two protease inhibitors, DPP-IV and Aprotinin (Sigma), were added immediately to the purple-top tubes specifically for preservation of NPY (Frerker, 2007). A protease inhibitor cocktail (Sigma) were added to the serum aliquot microtubes. The samples were centrifuged at 3500×g for 15 min at 4 °C, pipetted into the appropriate serum and plasma aliquots, and stored in a -80 degrees centigrade (C) freezer until ready for analysis. These samples were de-identified by labeling using a subject number, draw number, and date. Multiple aliquots of each sample were made to avoid freeze-thaw cycles and resulting sample degradation.

Blood Collection Scheme

At total of 12 samples were obtained throughout the experiment. Blood was drawn during pre-testing and post-testing (Weeks 1 and 14, respectively) to evaluate the effects of the nutritional and exercise interventions on the biomarkers of stress and resilience. To evaluate the effects of the interventions on resting biomarker levels *and*

biomarker release under stress, draws were scheduled around the VO_2 Max tests. The baseline draw (low stress) was performed at rest prior to the VO_2 Max test, and two draws (high stress) were performed after the VO_2 Max test - one immediately following and one 20 minutes following. These allowed for collection of biomarkers that release quickly in response to stress (NE, NPY, serotonin) and for those that have a delayed release (cortisol, DHEA-S). To further evaluate the effects of the interventions over time, three additional low stress draws were performed during the intervention on Weeks 4, 7, and 10 prior to exercise (at rest) on Fridays. The blood draw schedule for each participant and the specific biomarkers assessed from each draw is summarized in Table 3.

Table 3. Blood draw schedule. Blood was drawn three times during pre-testing and post-testing, and three times during the interventions for a total of nine draws. Blood was drawn under low and high stress conditions.

	Pre-Testing Blood Draws			Mid Training Blood Draws			Post-Testing Blood Draws		
Study Week	1			4	7	10	14		
Draw Timing	Test Day 1 Pre-VO_2 Max	Test Day 1 0 min Post-VO_2 Max	Test Day 1 20 min Post-VO_2 Max	Pre-Exercise (Friday)	Pre-Exercise (Friday)	Pre-Exercise (Friday)	Test Day 1 Pre-VO_2 Max	Test Day 1 0 min Post-VO_2 Max	Test Day 1 20 min Post-VO_2 Max
Biomarkers Analyzed	Cortisol DHEA-S NE NPY Serotonin	NE NPY Serotonin	Cortisol DHEA-S	Cortisol DHEA-S NE NPY Serotonin	Cortisol DHEA-S NE NPY Serotonin	Cortisol DHEA-S NE NPY Serotonin	Cortisol DHEA-S NE NPY Serotonin	NE NPY Serotonin	Cortisol DHEA-S

Biomarker Assay Procedure

Biomarkers of stress and resilience were evaluated via enzyme-linked immunosorbent assay (ELISA) by trained laboratory personnel. These biomarkers included: cortisol, dehydroepiandrosterone sulfate (DHEA-S), norepinephrine (NE), neuropeptide Y (NPY), and serotonin. To maintain sample integrity, assays were performed after the conclusion of each of the six cohorts.

All ELISA kits used were previously validated in human participants within the lab. Assays were strictly executed according to the instructions set forth in each kit. To minimize the effect of natural variation in each kit, products of the same lot were purchased for each cohort, standard curves were generated for each plate, and samples were randomly assigned to the plates. Each sample was run in duplicate and averaged. Samples that fell off the standard curve or had high (>30%) variation between duplicates were re-assayed. Plates were read using the Spectromax 180 Spectrophotometer and the resulting data were processed with the Softmax 7.0 software.

Cognitive Testing

Cognitive Function Battery (CFB)

To assess cognitive performance changes, participants performed the CFB, which comprises a series of computer-based cognitive performance tests using E-prime® software scripts. Each test in this battery reflects custom instantiations of well-validated cognitive performance tests, such as the digit span test for working memory (Baddeley & Hitch, 1974). These tests were administered at rest during baseline and post-testing

(Weeks 1 and 14). The list of tests and the cognitive functions they assess is summarized in Table 4.

Symbol-Digit Modalities Test (SDMT)

The SDMT is a single test designed to assess working memory. Unlike the CFB, this test was administered using pencil and paper and occurred immediately following the VO_2 Max test during both pre and post-testing. The administration of this test was designed to yield a measurement of cognitive performance under peak physical stress compared to the CFB which was administered at rest.

Table 4. Descriptions of the computer-based cognitive tests included in the Illinois Cognitive Function Battery (ICFB).

Illinois Cognitive Function Battery		
Test Name	Cog. Function Assessed	Duration (min)
Number Set	Fluid Intelligence	7
Letter Set	Fluid Intelligence	10
Digit Span	Working Memory	10
Rotational Span	Working Memory	11
Decision-Making	Executive Function	20
Keeping Track	Executive Function	16
Paired Associates	Episodic Memory	5
Immediate Free Recall (pictures)	Episodic Memory	8
Delayed pics Recall	Episodic Memory	3

Physical Testing

Baseline and Post-Testing Battery

A comprehensive physical test battery (summarized in Table 5) was developed by AFRL researchers to examine a broad set of physical performance characteristics deemed relevant for AF physical training and field operations. These tests were administered during baseline and post-testing (Weeks 1 and 14).

Table 5. Description of the physical performance tests included in the physical performance test battery that were administered at baseline and post-testing.

Physical Performance Test	Test Description	Performance Dimension Assessed
Body Weight	Stand still atop a high-performance electronic scale.	Gross body mass
Height	Assessed using a tape measure in accordance with USAF standards.	Vertical height
Resting Blood Pressure (BP)	The amount of pressure in the arteries during a heartbeat (systolic/top number) over the pressure in the arteries when the heart chambers are refilling (diastolic/bottom number) – a series of three readings taken at rest either manually or using an electronic BP monitor.	Normal: Approximately 120/80 mmHg
Resting Heart Rate (HR)	Number of heart beats per minute (bpm) at rest as assessed using an electronic BP monitor.	Used to predict maximal and exercise target zones; Normal adult range: 60-100 bpm
Body Fat Percentage (%)	DEXA - Determines an individual's overall and segmented body composition using X-ray technology.	Healthy body fat percentages for men ages 20-40: 8% to 21%; women ages 20 – 40: 21% to 32%
Lean Muscle Mass (lbs.)	DEXA - Determines an individual's overall and segmented body composition using X-ray technology.	Total muscle mass gained/lost
Push-ups	Administered according to USAF PT test standards. Properly complete as many push-ups as possible within 1-minute.	Strength and endurance of upper body and torso muscle groups.
Sit-ups	Administered according to USAF PT test standards. Properly complete as many sit-ups as possible within 1-minute.	Strength and endurance of torso muscle groups.
Abdominal Circumference	Assessed via hip circumference using a tape measure in accordance with USAF standards.	Maximal length around your hips; Reflective of abdominal fat composition measured in inches.
1.5 mile Run	Run 1.5 miles as fast as possible.	Cardiovascular fitness (time)
VO_2 max	Bruce Protocol – Walk/run on a treadmill with incremental increases in speed and incline to exhaustion while oxygen consumption was measured.	Maximal aerobic capacity ; Indicator of cardiorespiratory fitness; Average values: 35-46 ml/kg/min for men 18-45 years of age; 29-39 ml/kg/min for women 18-45 years of age
Wingate Cycle Ergometer Test (Upper and Lower Body)	Bicycle pedal (or arm crank) as fast as possible against a fixed resistance for 30 seconds.	Maximum and average peak anaerobic power

Vertical Jump	The best of 3 jumps measured using the standard Vertec procedures from a 2 foot static position.	Explosive lower extremity power Male avg.= 16-20 in Female avg. = 12-16 in
Standing Long Jump	The best of 3 longitudinal jumps from a 2-foot static position.	Explosive lower extremity power Male avg. = 7'3" – 7' 6.5" Female avg. = 5'1" – 6'0
Sled Push and Backpedal	Push (15 yd.) and pull (15 yd.) a 140lb sled 2x for a total of 60 yds. without stopping.	Total body anaerobic power and endurance (time)
Alternate Pull-up Test	As many pull-ups as possible until exhaustion in a modified position.	Upper body muscular endurance (reps)
300 yd. Sand Bag Carry	Run (30 yd.) with a 40 lb. sand bag, drop the bag; Run (30 yd.). Repeat 6x.	Total body endurance & speed (time)
Supine Bridge	Isometric hold in a supine bridge position. Test ends when the participant can no longer hold the bridge.	Trunk muscular endurance and control (time)
Lateral Bridge	Isometric hold in a lateral plank position for up to 30 sec.	Endurance strength of trunk lateral flexor (Grade 1-5).
Illinois Agility Test	Complete a weaving running course in the shortest possible time.	Speed and Agility (time)
Y-Balance Test	Multi-planar movement assessment to test dynamic balance.	Functional balance (summative score of 3 dimensions for lower and upper body)

12 Week Training Intervention

All participants underwent a novel, 12-week exercise training intervention. Participants were asked to attend 5 exercise sessions per week (Monday through Friday), with each session lasting approximately 1 hour. Participants with less than 80% attendance were excluded from data analysis. All exercise sessions included a warm-up, focal exercise routine, and a cool-down. These routines were developed by AFRL researchers which includes two certified and licensed Athletic Trainers with expertise in injury prevention and exercise rehabilitation. All participants were provided with a heart rate monitor to be worn during each exercise session in order to view and adjust their personal exercise intensity levels and rest periods.

Individual exercise routines focused on improving upper- and lower-body strength (Mondays and Wednesdays), active recovery, flexibility, and core strength (Tuesdays and Thursdays), and cardiovascular endurance training/HIIT (Fridays) (see Figure 1). Participants were guided on proper form for each exercise, and all exercise sessions were supervised by at least one member of the research staff.

Surveys/Questionnaires

Participants were asked to fill out surveys to obtain demographic information, assess subjective stress and resilience levels, and to determine eating and exercise habits. Well-validated surveys, especially those validated within military populations, were chosen. All surveys were taken during baseline and post-testing with the exception of the

Daily Nutritional Intake, which was administered over the course of the exercise intervention period. These surveys and their descriptions are listed below.

Demographic & Medical Screening Questionnaire Profile

This questionnaire was used to obtain basic demographic information about each participant, such as his/her military rank, education level, age, and gender. It was used by the medical monitor to screen participants for medical issues that may preclude eligibility, including the use of confounding prescription drugs or disease.

Life Stress Questionnaire-modified (LSQ)

The LSQ measures chronic life stressors (Lustman, Sowa, & Day, 1991). Wheatley (2009) condensed the LSQ to include only questions that operationalized chronic stress. The abridged version was used in this study. This questionnaire was used as a ground truth assessment, comparing participants' subjective stress levels with their stress biomarker levels. It was also used to validate outlying data. For example, biomarker data showing high stress levels at rest may have been caused by a recent deployment and not due to an error in lab work.

Brief Resilience Scale (BRS)

The BRS was designed to test an individual's ability to recover from stress (Windle, Bennett, & Noyes, 2011). The strategy in creating the scale was to use as few items as necessary to develop a reliable scale to assess resilience. There are an equal number of positive and negatively worded items to decrease the likelihood of positive

response bias (Smith et al., 2008). This scale was also used as a ground truth assessment, comparing participants' subjective resilience levels with their resilience biomarker levels.

Daily Nutritional Intake (DNI)

This 5-minute survey was developed by AFRL researchers in order to periodically assess participants' dietary intake, as well as sleeping habits, alcohol consumption, and nicotine use. Participants took this survey electronically once a week on varying days. While we expect that the nutrients contained in the supplement will enhance performance, participants may not experience this enhancement if they already consume a diet that contains the active ingredients. For example, DHA supplementation may not show a positive cognitive effect in participants who already consume a diet high in fish. Additionally, though each subject was advised to have at least 6 hours of sleep prior to testing, subjects were not excluded from testing based on their sleep habits. Inadequate sleep may increase cortisol levels and effect performance (Leproult, 1997). Physiological data was compared to the DNI to explain possible outliers or discrepancies.

RESULTS

A total of 130 subjects (58 in the High Nutrient Group and 72 in the Low Nutrient Group) completed the 12-week nutritional and exercise intervention with at least 80% workout attendance. Additional descriptive statistics for our subject population is given in Table 6.

Table 6. Descriptive characteristics of subjects (n= 130). On average, both groups had comparable physical attributes at baseline.

	High Nutrient Group	Low Nutrient Group
Total Subjects	58	72
Males	45	51
Females	13	21
Mean Age (yr)	30.3	30.1
Mean VO_2 Max (ml/kg/min)	43.6	45.2
Mean Lean Muscle Mass (lbs)	124.0	123.7
Mean Body Fat (%)	27.9	28.9

Statistical Analysis – Aim 1

Assessment of biomarker changes over the course of the intervention within (Aim 1a) and between (Aim 1b) the two groups was performed with the repeated measures analysis of variance (ANOVA) statistical test. A repeated measures ANOVA was run for each of the five biomarker variables under each type of stress condition - low stress (resting levels pre-VO2 Max), high stress (peak levels post-VO2 Max), and stress change (high stress minus low stress) with time point as the repeated measure. Age and gender were covaried for DHEA-S analysis, and time of day was covaried for cortisol analysis. Outlying data were evaluated for exclusion by cross-referencing the questionnaires and demographic information, as previously described. IBM SPSS Statistics version 25 was used for all primary analyses. SAS version 9.4 was used for post-hoc analyses. A level of significance alpha=0.05 was used throughout.

The results of the overall F-test for the within-subjects effects are given in Table 7, and the results for the between-subjects effects are given in Table 8. To account for any data lacking sphericity, the Greenhouse-Geisser statistic was used. P-values that are less than 0.05 indicate evidence of a significant difference between at least two of the time points. Variables where a significant difference was detected are indicated in boldface. Bonferroni's post hoc multiple comparison procedure was performed for each of the significant models with more than two time points (Table 9). This procedure adjusts the P-values of the pair-wise comparisons to control for a potentially inflated type I error that can result from running multiple tests. Therefore, the type I error rate for each

of the repeated measures ANOVAs is held constant at alpha=0.05. Plots of the statistically significant comparisons are given in Figures 2-6.

Statistical Analysis – Aim 2

Bivariate correlations were performed to assess the relationships between biomarker levels and physical and cognitive performance scores. Partial correlations were performed for cortisol to control for time of day and DHEA-S to control for age and gender. The Pearson correlation coefficients are given in Tables 10-39. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Shading begins at the Pearson correlation critical value for n=100 at alpha=.05.

Table 7: *P*-values for the overall F-tests for the Within-Subjects Effects. Highlighted values denote significance. High stress and stress change cortisol and low stress NPY levels decreased.

Response Variable	*P*-value
Cortisol (low stress)	0.138
Cortisol (high stress)	**0.030**
Cortisol (stress change)	**0.002**
DHEA-S (low stress)	0.749
DHEA-S (high stress)	0.744
DHEA-S (stress change)	0.918
NE (low stress)	0.608
NE (high stress)	0.657
NE (stress change)	0.532
NPY (low stress)	**0.010**
NPY (high stress)	0.080
NPY (stress change)	0.060
Serotonin (low stress)	0.340
Serotonin (high stress)	0.424
Serotonin (stress change)	0.217

Table 8: *P*-values for the overall F-tests for the Between-Subjects Effects. Highlighted values denote significance. High Stress NE levels decreased in the High Nutrient (experimental) group.

Response Variable	*P*-value
Cortisol (low stress)	0.842
Cortisol (high stress)	0.807
Cortisol (stress change)	0.672
DHEA-S (low stress)	0.851
DHEA-S (high stress)	0.670
DHEA-S (stress change)	0.747
NE (low stress)	0.243
NE (high stress)	**0.050**
NE (stress change)	0.069
NPY (low stress)	0.819
NPY (high stress)	0.654
NPY (stress change)	0.643
Serotonin (low stress)	0.984
Serotonin (high stress)	0.323
Serotonin (stress change)	0.545

Table 9: Results of Bonferroni's multiple comparison procedure for Low Stress NPY. The most relevant points of comparison (Baseline/Week 1 vs all other time points) were not significantly different.

Least Squares Means Estimates Adjustment for Multiplicity: Bonferroni												
Effect	Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P	Alpha	Lower	Upper	Adj Lower	Adj Upper
Time	Week 1 vs 4	-1.8044	0.7725	128.7	-2.34	0.0210	0.0842	0.05	-3.3327	-0.2760	-3.7612	0.1525
Time	Week 1 vs 7	-0.3863	0.7888	223.8	-0.49	0.6248	1.0000	0.05	-1.9408	1.1682	-2.3726	1.6000
Time	Week 1 vs 10	-0.5856	1.0218	238.7	-0.57	0.5671	1.0000	0.05	-2.5985	1.4273	-3.1572	1.9860
Time	Week 1 vs 14	1.2927	0.7706	259.2	1.68	0.0946	0.3786	0.05	-0.2247	2.8101	-0.6455	3.2309

Figure 2. Low Stress NPY levels pre- to post-intervention. The overall decreases in low stress/resting NPY levels pre- to post-intervention were not significant.

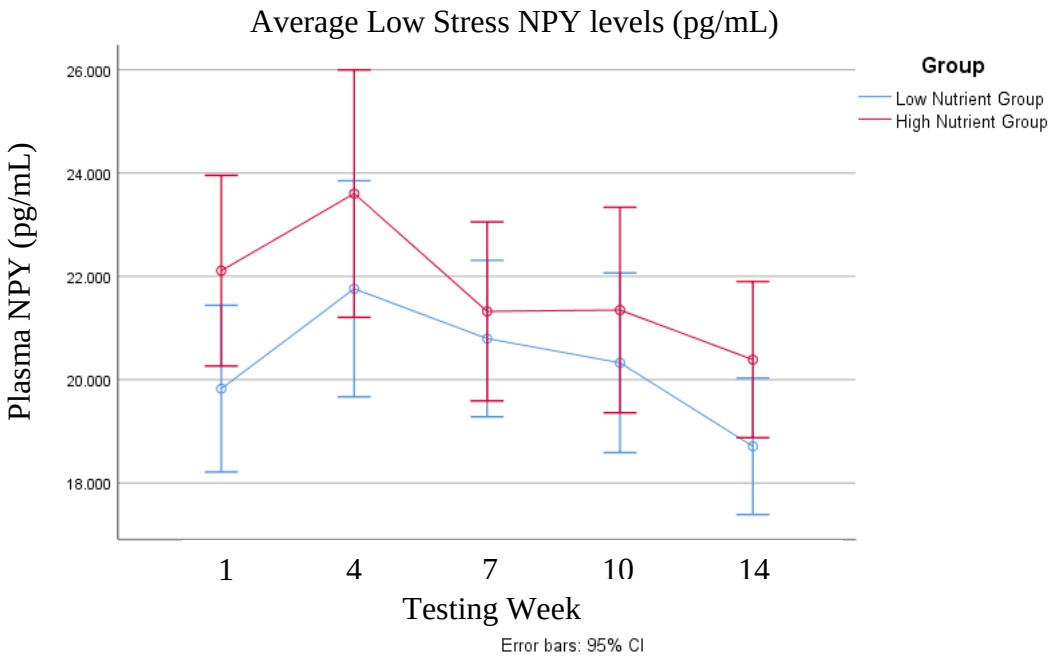
Average Low Stress NPY levels (pg/mL)
Plasma NPY (pg/mL)
26.000
24.000
22.000
20.000
18.000
1
4
7
10
14
Testing Week
Error bars: 95% CI
Group
Low Nutrient Group
High Nutrient Group

Figure 3. High Stress NE levels pre- to post-intervention. Average high stress condition NE levels decreased significantly in the High Nutrient Group (experimental) compared to the Low Nutrient Group (control) pre- to post-intervention.

Average High Stress NE levels (ng/mL)

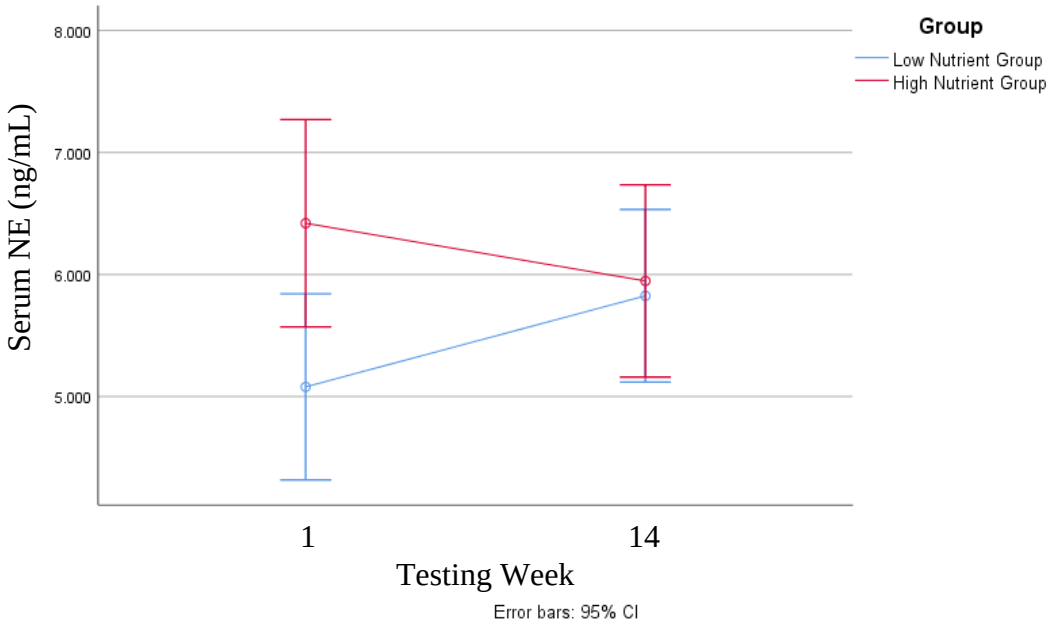

Figure 4. High Stress cortisol levels pre- to post-intervention. Average High Stress condition cortisol levels decreased significantly in both groups pre- to post-intervention.

Average High Stress Cortisol levels (µg/mL)

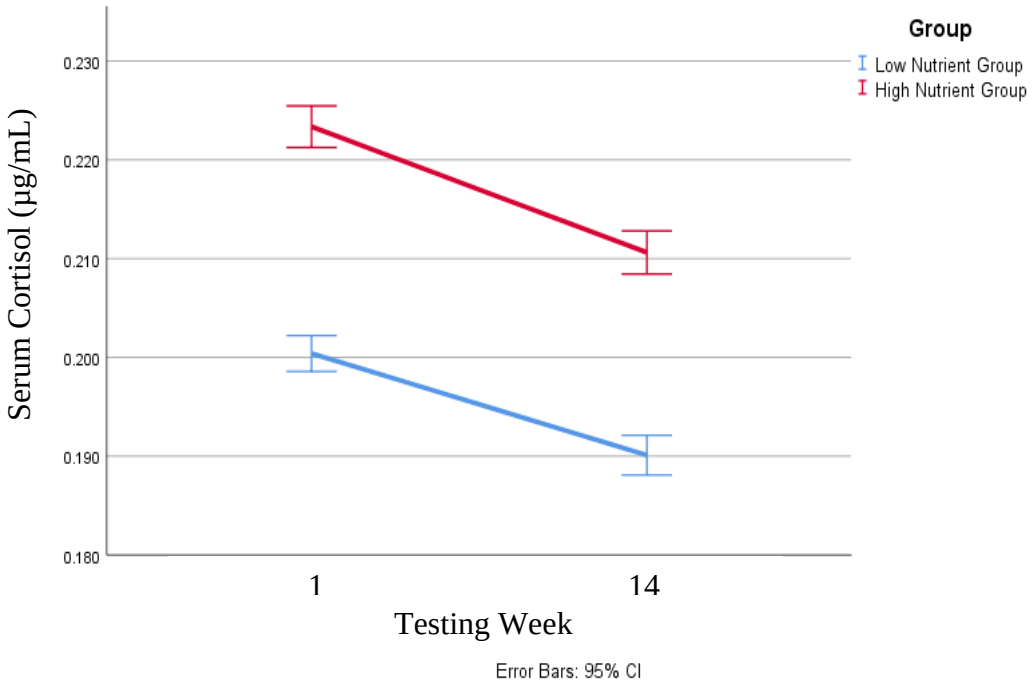

Figure 5. Cortisol level change from baseline to peak stress pre- to-post- intervention. Average cortisol level change from Low Stress to High Stress conditions decreased significantly in both groups pre- to post-intervention.

Average change in Cortisol levels (µg/mL) from baseline

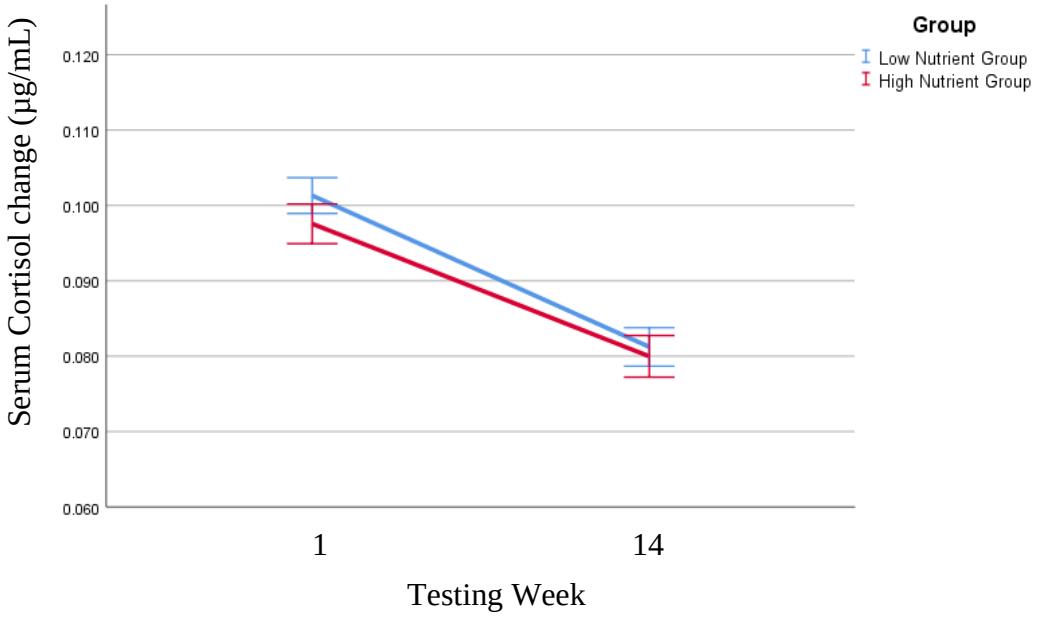

Table 10. Pearson Correlation Results. Cortisol levels compared to Anthropometric and Cardiac Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Pre-testing peak cortisol was negatively correlated with heart rate.

		CORTISOL					
		CORT BD1	CORT BD7	CORT BD3	CORT BD9	CORT BD3 - BD1	CORT BD9 - BD7
		Low Stress		High Stress		Stress Change	
ANTHRO-POMETRICS	WeightB	-0.074	-0.071	-0.001	-0.135	0.059	-0.046
	WeightP	-0.079	-0.060	0.018	-0.111	0.061	-0.072
	BodyFatB	0.002	-0.204	-0.174	-0.092	-0.164	-0.176
	BodyFatP	0.024	-0.185	-0.146	-0.095	-0.164	-0.208
	PreAbCir	-0.164	-0.089	-0.081	-0.165	0.030	-0.143
	PostAbCir	-0.129	-0.116	-0.045	-0.138	0.037	-0.148
	LMMB	-0.074	0.055	0.099	-0.065	0.137	0.054
	LMMP	-0.089	0.042	0.092	-0.058	0.134	0.042
CARDIAC	PreRestingHR	-0.083	0.110	-0.237	0.174	-0.242	-0.141
	PostRestingHR	-0.005	0.103	-0.207	0.173	-0.215	0.062
	PreSystolic	-0.032	0.024	0.086	0.051	-0.004	-0.035
	PostSystolic	-0.140	0.204	0.111	0.015	0.087	-0.057
	PreDiastolic	-0.062	0.172	0.078	0.126	0.013	-0.189
	PostDiastolic	-0.119	0.038	-0.061	0.093	-0.047	-0.101

Table 11. Pearson Correlation Results. Cortisol levels compared to Agility, Aerobic Power, Muscle Endurance, and Core Endurance Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Pre-testing high stress cortisol and stress-induced cortisol release was positively correlated with nearly all aspects of pre-testing performance scores and some post-testing performance scores, and negatively correlated with Agility. Agility is scored as time to course completion, therefore a lower number indicates a better score. Post-testing high stress and stress change cortisol were also positively correlated with some aspects of pre- and post-testing performance scores.

		CORTISOL					
		CORT BD1	CORT BD7	CORT BD3	CORT BD9	CORT BD3 - BD1	CORT BD9 - BD7
		Low Stress		High Stress		Stress Change	
AGILITY	PreAgility	-0.068	-0.192	-0.364	-0.174	-0.362	-0.144
	PostAgility	-0.038	-0.231	-0.315	-0.188	-0.317	-0.130
AEROBIC POWER	VO2MaxB	-0.006	0.280	0.211	0.100	0.204	0.093
	VO2MaxP	0.005	0.236	0.301	0.269	0.215	0.165
MUSCLE ENDURANCE	PrePushups	0.081	0.215	0.297	0.077	0.224	0.133
	PostPushups	0.032	0.165	0.274	0.026	0.255	0.129
	PreModPullUp	-0.141	0.123	0.150	0.038	0.249	0.195
	PostModPullUp	-0.120	0.148	0.156	0.036	0.244	0.192
CORE ENDURANCE	PreSitups	0.117	0.300	0.377	0.195	0.187	0.138
	PostSitups	0.093	0.349	0.353	0.173	0.276	0.168
	PreSupBridgeR	0.223	0.272	0.129	0.255	0.146	0.280
	PostSupBridgeR	0.059	0.156	0.041	0.104	0.113	0.147
	PreSupBridgeL	0.170	0.256	0.262	0.259	0.232	0.284
	PostSupBridgeL	0.087	0.157	0.090	0.132	0.134	0.193
	PreSupBridgeRL	0.207	0.276	0.202	0.269	0.195	0.291
	PostSupBridgeRL	0.075	0.160	0.067	0.120	0.127	0.175
	PreLatBridgeR	0.119	0.152	0.197	0.149	0.209	0.242
	PostLatBridgeR	0.142	0.119	0.138	0.122	0.114	0.225
	PreLatBridgeL	0.162	0.184	0.243	0.150	0.210	0.285
	PostLatBridgeL	0.062	0.115	0.044	0.058	0.107	0.157
	PreLatBridgeRL	0.145	0.174	0.227	0.155	0.218	0.275
	PostLatBridgeRL	0.105	0.120	0.094	0.092	0.114	0.197

Table 12. Pearson Correlation Results. Cortisol levels compared to Anaerobic Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Pre-testing high stress cortisol and stress-induced cortisol release was positively correlated with Long Jump and Wingate pre-testing performance scores, and negatively correlated with Rope Pull and Sled Push/Pull pre-testing performance scores. Rope Pull and Sled Push/Pull are scored as time to task completion, therefore a lower number indicates a better score.

		CORTISOL					
		CORT BD1	CORT BD7	CORT BD3	CORT BD9	CORT BD3 - BD1	CORT BD9 - BD7
		Low Stress		High Stress		Stress Change	
ANAEROBIC POWER	PreRolePullR	0.030	-0.097	-0.189	0.054	-0.268	0.049
	PostRolePullR	0.003	-0.112	-0.219	0.014	-0.278	0.023
	PreRolePullL	0.007	-0.088	-0.143	0.075	-0.179	0.086
	PostRolePullL	-0.017	-0.098	-0.208	-0.010	-0.240	0.005
	PreRolePullRL	0.018	-0.094	-0.167	0.067	-0.225	0.069
	PostRolePullRL	-0.008	-0.106	-0.217	0.001	-0.265	0.014
	PreLongJump	0.009	0.195	0.290	0.114	0.252	0.071
	PostLongJump	-0.030	0.222	0.268	0.081	0.256	0.057
	PreRotSBTossR	-0.132	0.109	0.154	-0.079	0.166	-0.053
	PostRotSBTossR	-0.103	0.056	0.152	-0.034	0.168	-0.002
	PreRotSBTossL	-0.126	0.064	0.151	-0.105	0.143	-0.083
	PostRotSBTossL	-0.138	0.084	0.163	-0.033	0.172	-0.029
	PreRotSBTossRL	-0.130	0.087	0.153	-0.092	0.156	-0.068
	PostRotSBTossRL	-0.121	0.071	0.159	-0.034	0.171	-0.016
	PreSledPushPull	0.056	-0.081	-0.228	0.031	-0.320	-0.030
	PostSledPushPull	0.060	-0.203	-0.246	-0.065	-0.340	-0.073
	PreUpperWingatePeakW	-0.131	0.082	0.150	-0.046	0.172	-0.113
	PostUpperWingatePeakW	-0.214	0.038	0.072	-0.060	0.098	-0.043
	PreUpperWingatePeakWkg	-0.092	0.142	0.256	0.023	0.214	-0.092
	PostUpperWingatePeakWkg	-0.216	0.060	0.115	-0.018	0.121	0.015
	PreUpperWingateAvgW	-0.137	0.093	0.151	-0.083	0.192	-0.145
	PostUpperWingateAvgW	-0.188	0.048	0.095	-0.047	0.125	-0.032
	PreUpperWingateAvgWkg	-0.094	0.146	0.249	-0.037	0.239	-0.134
	PostUpperWingateAvgWkg	-0.174	0.075	0.152	0.002	0.157	0.036
	PreLowerWingatePeakW	-0.118	0.162	0.130	-0.024	0.274	-0.054
	PostLowerWingatePeakW	-0.126	0.085	0.144	-0.031	0.204	-0.050
	PreLowerWingatePeakWkg	-0.034	0.256	0.208	0.059	0.283	-0.030

	PostLowerWingatePeakWkg	-0.065	0.170	0.236	0.062	0.273	0.043
	PreLowerWingateAvgW	-0.113	0.144	0.134	-0.048	0.272	-0.045
	PostLowerWingateAvgW	-0.089	0.113	0.179	-0.021	0.235	-0.018
	PreLowerWingateAvgWkg	-0.069	0.198	0.218	0.051	0.318	0.030
	PostLowerWingateAvgWkg	-0.001	0.203	0.286	0.075	0.312	0.094

Table 13. Pearson Correlation Results. Cortisol levels compared to Balance Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Pre-testing high stress cortisol and stress-induced cortisol release was positively correlated with nearly all aspects of pre-testing Y-Balance performance scores and some post-testing Y-Balance performance scores.

		CORTISOL					
		CORT BD1	CORT BD7	CORT BD3	CORT BD9	CORT BD3 - BD1	CORT BD9 - BD7
		Low Stress		High Stress		Stress Change	
BALANCE	PreUpperYBTMedR	-0.038	0.144	0.136	-0.102	0.275	0.041
	PostUpperYBTMedR	-0.109	0.010	0.038	-0.053	0.146	0.042
	PreUpperYBTILR	0.009	0.200	0.208	-0.011	0.264	0.064
	PostUpperYBTILR	-0.124	0.019	0.029	-0.059	0.185	0.082
	PreUpperYBTSLR	0.137	0.059	0.270	0.044	0.296	0.126
	PostUpperYBTSLR	0.081	0.028	0.142	0.162	0.153	0.141
	PreUpperYBTMedL	-0.016	0.131	0.150	-0.033	0.224	-0.008
	PostUpperYBTMedL	-0.143	0.011	-0.009	-0.105	0.111	0.011
	PreUpperYBTILL	-0.056	0.092	0.085	-0.102	0.241	-0.038
	PostUpperYBTILL	-0.084	-0.094	0.070	-0.051	0.151	0.090
	PreUpperYBTSLL	0.174	0.059	0.312	0.101	0.255	0.064
	PostUpperYBTSLL	0.087	-0.026	0.145	0.086	0.166	0.100
	PreUpperYBTCOMR	0.117	0.209	0.270	0.070	0.322	0.147
	PostUpperYBTCOMR	0.001	0.060	0.097	0.107	0.185	0.165
	PreUpperYBTCOML	0.107	0.149	0.225	0.066	0.271	0.046
	PostUpperYBTCOML	0.018	-0.011	0.101	0.074	0.166	0.147
	PreUpperYBTRL	0.115	0.178	0.261	0.066	0.310	0.098
	PostUpperYBTRL	0.005	0.029	0.105	0.095	0.183	0.160
	PreLowerYBTAntR	0.056	0.048	0.158	-0.059	0.178	-0.012
	PostLowerYBTAntR	-0.094	0.108	0.098	-0.020	0.133	-0.098
	PreLowerYBTAntL	0.085	0.112	0.157	-0.060	0.143	-0.063
	PostLowerYBTAntL	-0.020	0.062	0.088	0.036	0.132	0.011
	PreLowerYBTPMR	0.031	0.163	0.269	0.010	0.281	0.010
	PostLowerYBTPMR	-0.072	0.097	0.160	-0.016	0.223	-0.019
	PreLowerYBTPML	-0.008	0.126	0.222	0.012	0.281	0.014
	PostLowerYBTPML	-0.047	0.042	0.132	0.002	0.199	0.038
	PreLowerYBTPLR	-0.016	0.088	0.206	-0.045	0.267	0.002

	PostLowerYBTPLR	-0.057	0.123	0.203	0.068	0.267	0.028
	PreLowerYBTPLL	0.011	0.101	0.166	-0.036	0.257	-0.023
	PostLowerYBTPLL	-0.039	0.171	0.134	0.060	0.202	0.005
	PreLowerYBTCOMR	0.085	0.159	0.237	0.070	0.294	0.087
	PostLowerYBTCOMR	-0.035	0.151	0.148	0.116	0.250	0.057
	PreLowerYBTCOML	0.086	0.153	0.191	0.066	0.280	0.063
	PostLowerYBTCOML	0.013	0.141	0.099	0.143	0.214	0.113
	PreLowerYBTRL	0.086	0.164	0.211	0.065	0.288	0.069
	PostLowerYBTRL	-0.015	0.146	0.128	0.133	0.244	0.087

Table 14. Pearson Correlation Results. DHEA-S levels compared to Anthropometric and Cardiac Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Post-testing stress-induced DHEA-S release was positively correlated with Abdominal Circumference and pre-resting heart rate, systolic pressure, and post diastolic pressure.

		DHEA-S					
		DHEAS BD1	DHEAS BD7	DHEAS BD3	DHEAS BD9	DHEAS BD3 - BD1	DHEAS BD9 - BD7
		Low Stress		High Stress		Stress Change	
ANTHRO-POMETRICS	WeightB	-0.041	-0.021	-0.114	-0.059	0.026	0.089
	WeightP	-0.012	0.017	-0.091	-0.019	0.043	0.103
	BodyFatB	0.136	0.104	-0.016	0.027	-0.037	0.055
	BodyFatP	0.129	0.082	-0.011	0.010	-0.060	0.028
	PreAbCir	-0.035	-0.043	-0.145	0.003	-0.014	0.204
	PostAbCir	0.024	0.009	-0.113	0.036	-0.020	0.200
	LMMB	-0.113	-0.096	-0.081	-0.073	0.015	0.026
	LMMP	-0.060	-0.011	-0.056	0.001	0.067	0.078
CARDIAC	PreRestingHR	0.123	0.068	-0.012	0.257	-0.073	0.321
	PostRestingHR	-0.053	0.005	0.020	0.106	0.082	0.099
	PreSystolic	0.006	0.018	-0.032	0.183	0.018	0.262
	PostSystolic	-0.054	0.011	0.096	0.143	0.091	0.036
	PreDiastolic	0.156	0.097	0.008	0.167	-0.075	0.186
	PostDiastolic	0.021	0.024	-0.093	0.087	0.006	0.231

Table 15. Pearson Correlation Results. DHEA-S levels compared to Agility, Aerobic Power, Muscle Endurance, and Core Endurance Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Pre-testing high stress DHEA-S was positively correlated with all aspects of post-testing performance scores except VO_2 Max and Sit-ups, and negatively correlated with Agility scores. Agility is scored as time to course completion, therefore a lower number indicates a better score. This pattern was flipped with post-testing stress-induced release DHEA-S levels in that they were negatively correlated with most performance scores, and positively correlated with Agility.

		DHEA-S					
		DHEAS BD1	DHEAS BD7	DHEAS BD3	DHEAS BD9	DHEAS BD3 - BD1	DHEAS BD9 - BD7
		Low Stress		High Stress		Stress Change	
AGILITY	PreAgility	-0.101	-0.090	-0.274	-0.127	0.008	0.229
	PostAgility	-0.024	-0.055	-0.230	-0.188	-0.047	0.095
AEROBIC POWER	VO2MaxB	-0.028	0.025	0.046	-0.067	0.077	-0.142
	VO2MaxP	-0.179	-0.046	-0.053	-0.089	0.183	-0.032
MUSCLE ENDURANCE	PrePushups	-0.081	-0.054	0.264	0.005	0.034	-0.359
	PostPushups	-0.036	-0.017	0.216	-0.002	0.026	-0.301
	PreModPullUp	-0.030	0.005	0.171	0.081	0.049	-0.141
	PostModPullUp	0.229	0.268	0.436	0.285	0.077	-0.266
CORE ENDURANCE	PreSitups	0.036	-0.016	0.141	0.081	-0.074	-0.099
	PostSitups	0.011	0.053	0.144	0.077	0.062	-0.109
	PreSupBridgeR	-0.058	0.015	0.108	0.036	0.103	-0.107
	PostSupBridgeR	0.114	0.165	0.213	0.113	0.085	-0.162
	PreSupBridgeL	-0.033	-0.021	0.178	-0.024	0.016	-0.275
	PostSupBridgeL	0.145	0.149	0.294	0.130	0.017	-0.253
	PreSupBridgeRL	-0.049	-0.003	0.150	0.007	0.064	-0.199
	PostSupBridgeRL	0.132	0.160	0.260	0.124	0.052	-0.212
	PreLatBridgeR	-0.017	-0.061	0.147	0.011	-0.066	-0.191
	PostLatBridgeR	0.127	0.147	0.318	0.155	0.039	-0.256
	PreLatBridgeL	0.015	0.019	0.189	0.039	0.008	-0.217
	PostLatBridgeL	0.080	0.067	0.225	0.070	-0.014	-0.229
	PreLatBridgeRL	-0.002	-0.023	0.174	0.025	-0.031	-0.211
	PostLatBridgeRL	0.106	0.109	0.279	0.115	0.013	-0.250

Table 16. Pearson Correlation Results. DHEA-S levels compared to Anaerobic Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. DHEA-S levels were associated with very few aspects of Anaerobic Performance.

		DHEA-S					
		DHEAS BD1	DHEAS BD7	DHEAS BD3	DHEAS BD9	DHEAS BD3 - BD1	DHEAS BD9 - BD7
		Low Stress		High Stress		Stress Change	
ANAEROBIC POWER	PreRolePullR	-0.040	-0.003	-0.148	-0.060	0.052	0.134
	PostRolePullR	-0.062	-0.044	-0.096	-0.047	0.021	0.078
	PreRolePullL	-0.073	-0.033	-0.174	-0.124	0.053	0.093
	PostRolePullL	-0.020	-0.088	-0.127	-0.034	-0.103	0.136
	PreRolePullRL	-0.059	-0.020	-0.165	-0.096	0.054	0.114
	PostRolePullRL	-0.041	-0.069	-0.116	-0.041	-0.045	0.111
	PreLongJump	0.043	-0.004	0.224	0.182	-0.066	-0.096
	PostLongJump	-0.020	-0.030	0.214	0.105	-0.016	-0.171
	PreRotSBTossR	-0.117	-0.095	0.031	0.064	0.023	0.033
	PostRotSBTossR	-0.112	-0.108	-0.092	-0.025	-0.003	0.099
	PreRotSBTossL	-0.137	-0.150	-0.048	-0.027	-0.029	0.035
	PostRotSBTossL	-0.120	-0.128	-0.148	-0.052	-0.022	0.144
	PreRotSBTossRL	-0.129	-0.124	-0.009	0.019	-0.003	0.035
	PostRotSBTossRL	-0.117	-0.119	-0.121	-0.039	-0.012	0.122
	PreSledPushPull	0.064	0.084	-0.109	-0.048	0.035	0.094
	PostSledPushPull	0.035	-0.055	-0.189	-0.188	-0.131	0.040
	PreUpperWingatePeakW	-0.125	-0.050	-0.014	0.120	0.101	0.161
	PostUpperWingatePeakW	-0.157	-0.064	-0.077	0.091	0.125	0.214
	PreUpperWingatePeakWkg	-0.115	-0.022	0.079	0.138	0.129	0.054
	PostUpperWingatePeakWkg	-0.176	-0.062	0.001	0.065	0.155	0.075
	PreUpperWingateAvgW	-0.125	-0.095	0.006	0.037	0.033	0.036
	PostUpperWingateAvgW	-0.154	-0.076	-0.067	0.058	0.104	0.161
	PreUpperWingateAvgWkg	-0.100	-0.069	0.119	0.037	0.038	-0.120
	PostUpperWingateAvgWkg	-0.171	-0.073	0.025	0.026	0.131	-0.004
	PreLowerWingatePeakW	-0.116	-0.077	0.029	0.047	0.049	0.016
	PostLowerWingatePeakW	-0.031	-0.039	0.082	0.160	-0.015	0.075
	PreLowerWingatePeakWkg	-0.115	-0.063	0.133	0.007	0.067	-0.175

	PostLowerWingatePeakWkg	-0.026	-0.059	0.231	0.150	-0.051	-0.143
	PreLowerWingateAvgW	-0.120	-0.077	0.027	0.008	0.054	-0.028
	PostLowerWingateAvgW	-0.029	-0.008	0.064	0.153	0.029	0.092
	PreLowerWingateAvgWkg	-0.083	0.007	0.142	0.044	0.127	-0.145
	PostLowerWingateAvgWkg	-0.017	-0.006	0.216	0.143	0.015	-0.129

Table 17. Pearson Correlation Results. DHEA-S levels compared to Balance Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. DHEA-S levels were associated with very few aspects of Balance.

		DHEA-S					
		DHEAS BD1	DHEAS BD7	DHEAS BD3	DHEAS BD9	DHEAS BD3 - BD1	DHEAS BD9 - BD7
		Low Stress		High Stress		Stress Change	
BALANCE	PreUpperYBTMedR	0.013	0.069	0.115	0.156	0.083	0.027
	PostUpperYBTMedR	-0.062	0.038	0.048	0.132	0.143	0.091
	PreUpperYBTILR	0.168	0.157	0.230	0.185	-0.003	-0.100
	PostUpperYBTILR	0.043	-0.005	0.051	0.054	-0.067	-0.007
	PreUpperYBTSLR	0.118	0.085	0.081	0.012	-0.041	-0.097
	PostUpperYBTSLR	0.097	0.053	0.043	0.042	-0.058	-0.010
	PreUpperYBTMedL	-0.045	-0.003	0.002	0.101	0.058	0.116
	PostUpperYBTMedL	-0.021	0.076	0.014	0.106	0.142	0.105
	PreUpperYBTILL	0.046	0.052	0.023	0.105	0.013	0.093
	PostUpperYBTILL	-0.069	-0.124	-0.112	-0.047	-0.086	0.100
	PreUpperYBTSLL	0.054	0.006	-0.075	-0.092	-0.066	-0.006
	PostUpperYBTSLL	0.027	-0.025	-0.128	-0.081	-0.075	0.082
	PreUpperYBTCOMR	0.165	0.153	0.251	0.155	-0.005	-0.164
	PostUpperYBTCOMR	0.056	0.050	0.115	0.095	-0.005	-0.047
	PreUpperYBTCOML	0.064	0.054	0.053	0.060	-0.009	-0.002
	PostUpperYBTCOML	0.006	-0.012	-0.024	0.003	-0.026	0.037
	PreUpperYBTRL	0.110	0.102	0.152	0.108	-0.003	-0.083
	PostUpperYBTRL	0.040	0.020	0.057	0.055	-0.027	-0.014
	PreLowerYBTAntR	0.067	0.053	0.095	0.077	-0.015	-0.041
	PostLowerYBTAntR	-0.019	-0.068	-0.013	0.087	-0.073	0.120
	PreLowerYBTAntL	-0.035	-0.063	-0.040	-0.068	-0.044	-0.024
	PostLowerYBTAntL	0.014	-0.032	0.063	0.087	-0.067	0.016
	PreLowerYBTPMR	0.093	0.046	0.087	0.074	-0.062	-0.033
	PostLowerYBTPMR	0.010	-0.052	0.105	-0.003	-0.091	-0.148
	PreLowerYBTPML	0.036	0.008	0.123	0.052	-0.039	-0.109
	PostLowerYBTPML	0.100	0.040	0.051	0.071	-0.080	0.013
	PreLowerYBTPLR	0.123	0.095	0.090	0.026	-0.031	-0.093

	PostLowerYBTPLR	0.100	0.006	0.087	0.097	-0.131	-0.006
	PreLowerYBTPLL	0.118	0.075	0.049	0.077	-0.054	0.024
	PostLowerYBTPLL	0.094	0.070	0.048	0.049	-0.030	-0.009
	PreLowerYBTCOMR	0.186	0.119	0.195	0.104	-0.085	-0.147
	PostLowerYBTCOMR	0.114	0.010	0.165	0.103	-0.145	-0.106
	PreLowerYBTCOML	0.123	0.057	0.141	0.060	-0.089	-0.124
	PostLowerYBTCOML	0.154	0.081	0.153	0.119	-0.096	-0.071
	PreLowerYBTRL	0.157	0.086	0.176	0.087	-0.093	-0.141
	PostLowerYBTRL	0.135	0.043	0.165	0.116	-0.126	-0.092

Table 18. Pearson Correlation Results. NE levels compared to Anthropometric and Cardiac Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association.

		NOREPINEPHRINE					
		NE BD1	NE BD7	NE BD2	NE BD8	NE BD2 - BD1	NE BD8 - BD7
		Low Stress		High Stress		Stress Change	
ANTHRO-POMETRICS	WeightB	-0.150	0.034	-0.041	-0.012	-0.021	-0.016
	WeightP	-0.146	0.048	-0.043	-0.030	-0.023	-0.037
	BodyFatB	-0.099	0.049	-0.316	-0.166	-0.306	-0.174
	BodyFatP	-0.141	0.027	-0.318	-0.171	-0.302	-0.176
	PreAbCir	-0.130	0.073	-0.015	-0.018	0.002	-0.028
	PostAbCir	-0.163	0.066	-0.042	-0.035	-0.021	-0.044
	LMMB	-0.093	-0.007	0.121	0.069	0.134	0.071
	LMMP	-0.075	0.025	0.125	0.058	0.137	0.055
CARDIAC	PreRestingHR	0.144	0.050	-0.070	0.054	-0.090	0.048
	PostRestingHR	0.152	-0.044	-0.246	-0.080	-0.269	-0.075
	PreSystolic	0.071	0.150	0.168	0.015	0.160	-0.004
	PostSystolic	-0.064	0.044	0.127	0.056	0.137	0.051
	PreDiastolic	0.131	0.110	0.187	0.086	0.171	0.073
	PostDiastolic	0.205	0.206	0.142	0.134	0.116	0.108

Table 19. Pearson Correlation Results. NE levels compared to Agility, Aerobic Power, Muscle Endurance, and Core Endurance Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association.

		NOREPINEPHRINE					
		NE BD1	NE BD7	NE BD2	NE BD8	NE BD2 - BD1	NE BD8 - BD7
		Low Stress		High Stress		Stress Change	
AGILITY	PreAgility	0.020	0.078	-0.289	-0.129	-0.295	-0.140
	PostAgility	0.023	0.047	-0.323	-0.168	-0.33	-0.176
AEROBIC POWER	VO2MaxB	-0.019	-0.136	0.279	0.143	0.285	0.162
	VO2MaxP	0.097	-0.118	0.258	0.161	0.248	0.178
MUSCLE ENDURANCE	PrePushups	0.027	0.043	0.253	0.086	0.252	0.082
	PostPushups	0.044	0.015	0.237	0.063	0.234	0.062
	PreModPullUp	-0.003	0.001	0.187	0.151	0.189	0.152
	PostModPullUp	-0.021	0.003	0.221	0.121	0.226	0.122
CORE ENDURANCE	PreSitups	0.092	0.034	0.254	0.095	0.244	0.091
	PostSitups	0.068	0.054	0.174	0.082	0.167	0.076
	PreSupBridgeR	-0.002	-0.128	0.058	0.006	0.059	0.022
	PostSupBridgeR	0.095	-0.057	0.028	0.083	0.016	0.091
	PreSupBridgeL	0.076	-0.110	0.127	0.047	0.118	0.061
	PostSupBridgeL	0.096	-0.030	0.061	0.056	0.049	0.061
	PreSupBridgeRL	0.038	-0.123	0.095	0.027	0.091	0.043
	PostSupBridgeRL	0.098	-0.044	0.046	0.071	0.033	0.077
	PreLatBridgeR	0.059	-0.068	0.065	0.129	0.058	0.139
	PostLatBridgeR	0.041	-0.005	0.015	0.108	0.009	0.109
	PreLatBridgeL	0.103	-0.078	0.182	0.174	0.170	0.186
	PostLatBridgeL	0.029	-0.036	0.023	0.117	0.020	0.123
	PreLatBridgeRL	0.085	-0.076	0.130	0.158	0.120	0.169
	PostLatBridgeRL	0.036	-0.022	0.020	0.116	0.015	0.120

Table 20. Pearson Correlation Results. NE levels compared to Anaerobic Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association.

		NOREPINEPHRINE					
		NE BD1	NE BD7	NE BD2	NE BD8	NE BD2 - BD1	NE BD8 - BD7
		Low Stress		High Stress		Stress Change	
ANAEROBIC POWER	PreRolePullR	0.116	0.039	-0.211	-0.070	-0.229	-0.076
	PostRolePullR	0.035	-0.050	-0.224	-0.123	-0.231	-0.117
	PreRolePullL	0.068	-0.036	-0.213	-0.093	-0.224	-0.089
	PostRolePullL	0.040	-0.065	-0.195	-0.068	-0.203	-0.061
	PreRolePullRL	0.093	0.000	-0.216	-0.083	-0.231	-0.084
	PostRolePullRL	0.038	-0.059	-0.214	-0.097	-0.222	-0.090
	PreLongJump	-0.023	-0.050	0.254	0.175	0.26	0.184
	PostLongJump	-0.038	-0.064	0.212	0.152	0.219	0.162
	PreRotSBTossR	-0.036	0.101	0.212	0.165	0.219	0.154
	PostRotSBTossR	-0.036	0.077	0.218	0.144	0.225	0.135
	PreRotSBTossL	-0.026	0.094	0.234	0.163	0.24	0.153
	PostRotSBTossL	-0.046	0.058	0.222	0.129	0.231	0.123
	PreRotSBTossRL	-0.031	0.098	0.224	0.165	0.231	0.154
	PostRotSBTossRL	-0.041	0.068	0.222	0.137	0.23	0.130
	PreSledPushPull	0.043	-0.034	-0.26	-0.151	-0.268	-0.148
	PostSledPushPull	0.045	0.039	-0.241	-0.074	-0.25	-0.079
	PreUpperWingatePeakW	-0.056	0.097	0.153	0.065	0.162	0.053
	PostUpperWingatePeakW	-0.002	0.136	0.176	0.115	0.178	0.098
	PreUpperWingatePeakWkg	-0.042	0.056	0.256	0.099	0.264	0.092
	PostUpperWingatePeakWkg	0.040	0.110	0.275	0.165	0.273	0.152
	PreUpperWingateAvgW	-0.059	0.113	0.147	0.082	0.157	0.067
	PostUpperWingateAvgW	-0.012	0.148	0.173	0.140	0.177	0.122
	PreUpperWingateAvgWkg	-0.046	0.074	0.247	0.118	0.255	0.110
	PostUpperWingateAvgWkg	0.032	0.123	0.274	0.2	0.273	0.185
	PreLowerWingatePeakW	-0.141	-0.008	0.146	0.062	0.167	0.064
	PostLowerWingatePeakW	-0.061	0.059	0.158	0.059	0.167	0.052
	PreLowerWingatePeakWkg	-0.068	-0.067	0.217	0.102	0.229	0.112

	PostLowerWingatePeakWkg	-0.001	0.005	0.277	0.101	0.28	0.101
	PreLowerWingateAvgW	-0.128	0.021	0.165	0.056	0.184	0.054
	PostLowerWingateAvgW	-0.072	0.062	0.195	0.086	0.206	0.078
	PreLowerWingateAvgWkg	-0.086	-0.012	0.275	0.127	0.29	0.130
	PostLowerWingateAvgWkg	-0.019	0.008	0.315	0.135	0.321	0.135

Table 21. Pearson Correlation Results. NE levels compared to Balance Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. NE levels were associated with very few aspects of Balance.

		NOREPINEPHRINE					
		NE BD1	NE BD7	NE BD2	NE BD8	NE BD2 - BD1	NE BD8 - BD7
		Low Stress		High Stress		Stress Change	
BALANCE	PreUpperYBTMedR	-0.017	-0.093	0.150	0.050	0.154	0.062
	PostUpperYBTMedR	0.011	-0.054	0.130	0.022	0.130	0.029
	PreUpperYBTILR	-0.122	-0.154	0.063	-0.005	0.080	0.015
	PostUpperYBTILR	-0.052	-0.105	0.098	0.041	0.106	0.055
	PreUpperYBTSLR	0.043	-0.043	0.133	0.148	0.128	0.155
	PostUpperYBTSLR	0.060	-0.019	0.107	0.174	0.100	0.178
	PreUpperYBTMedL	0.027	-0.061	0.148	0.039	0.146	0.047
	PostUpperYBTMedL	-0.018	-0.047	0.110	-0.015	0.114	-0.009
	PreUpperYBTILL	-0.154	-0.104	0.095	0.018	0.116	0.031
	PostUpperYBTILL	-0.058	-0.127	0.104	0.021	0.113	0.037
	PreUpperYBTSLL	0.001	-0.023	0.225	0.198	0.227	0.203
	PostUpperYBTSLL	0.019	0.003	0.092	0.123	0.091	0.124
	PreUpperYBTCOMR	-0.036	-0.163	0.086	0.035	0.092	0.056
	PostUpperYBTCOMR	0.008	-0.120	0.087	0.052	0.087	0.068
	PreUpperYBTCOML	-0.058	-0.125	0.133	0.053	0.142	0.070
	PostUpperYBTCOML	-0.021	-0.123	0.079	0.006	0.083	0.022
	PreUpperYBTRL	-0.051	-0.147	0.118	0.051	0.126	0.070
	PostUpperYBTRL	-0.005	-0.127	0.081	0.034	0.083	0.051
	PreLowerYBTAntR	-0.061	-0.071	0.073	0.004	0.082	0.013
	PostLowerYBTAntR	-0.136	0.010	0.020	-0.022	0.039	-0.023
	PreLowerYBTAntL	-0.145	-0.077	0.121	0.019	0.142	0.029
	PostLowerYBTAntL	-0.101	-0.049	0.067	0.066	0.082	0.073
	PreLowerYBTPMR	-0.101	-0.120	0.166	0.099	0.182	0.116
	PostLowerYBTPMR	-0.108	-0.061	0.133	0.063	0.149	0.071
	PreLowerYBTPML	-0.159	-0.102	0.141	0.112	0.164	0.126
	PostLowerYBTPML	-0.101	-0.059	0.142	0.044	0.158	0.052
	PreLowerYBTPLR	-0.127	-0.045	0.104	0.057	0.123	0.063

	PostLowerYBTPLR	-0.046	-0.014	0.126	0.056	0.133	0.059
	PreLowerYBTPLL	-0.147	-0.107	0.121	0.033	0.142	0.048
	PostLowerYBTPLL	-0.054	-0.061	0.112	0.071	0.121	0.079
	PreLowerYBTCOMR	-0.137	-0.137	0.023	0.053	0.042	0.072
	PostLowerYBTCOMR	-0.135	-0.079	-0.015	0.017	0.003	0.028
	PreLowerYBTCOML	-0.208	-0.160	0.038	0.054	0.066	0.076
	PostLowerYBTCOML	-0.125	-0.107	0.008	0.054	0.025	0.069
	PreLowerYBTRL	-0.171	-0.150	0.027	0.051	0.051	0.071
	PostLowerYBTRL	-0.130	-0.092	-0.001	0.041	0.017	0.053

Table 22. Pearson Correlation Results. NPY levels compared to Anthropometric and Cardiac Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Pre-testing high stress and stress-induced release of NPY were associated with lower Weight. Pre- and post-testing high stress and stress-induced release of NPY were strongly associated with lower Abdominal Circumference and Body Fat percentage measures.

		NPY					
		NPY BD1	NPY BD7	NPY BD2	NPY BD8	NPY BD2 - BD1	NPY BD8 - BD7
		Low Stress		High Stress		Stress Change	
ANTHRO-POMETRICS	WeightB	0.068	0.033	-0.216	-0.162	-0.222	-0.165
	WeightP	0.079	0.053	-0.212	-0.164	-0.219	-0.167
	BodyFatB	-0.003	-0.007	-0.396	-0.347	-0.4	-0.35
	BodyFatP	-0.019	-0.006	-0.399	-0.355	-0.402	-0.358
	PreAbCir	0.098	0.031	-0.264	-0.238	-0.272	-0.242
	PostAbCir	0.115	0.085	-0.26	-0.232	-0.268	-0.238
	LMMB	0.069	0.038	0.004	0.027	0.000	0.026
	LMMP	0.086	0.057	-0.002	0.027	-0.006	0.025
CARDIAC	PreRestingHR	-0.166	-0.126	-0.131	-0.088	-0.123	-0.084
	PostRestingHR	-0.043	-0.056	-0.009	0.057	-0.008	0.060
	PreSystolic	0.110	0.153	-0.048	-0.001	-0.054	-0.007
	PostSystolic	0.159	0.136	-0.026	-0.072	-0.034	-0.078
	PreDiastolic	0.105	0.080	0.021	-0.024	0.017	-0.028
	PostDiastolic	0.042	-0.033	-0.043	-0.069	-0.045	-0.069

Table 23. Pearson Correlation Results. NPY levels compared to Agility, Aerobic Power, Muscle Endurance, and Core Endurance Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Pre- and post-testing high stress and stress-induced release of NPY were strongly associated with better scores for every aspect of Agility, Aerobic Power, Muscle Endurance, and Core Endurance.

		NPY					
		NPY BD1	NPY BD7	NPY BD2	NPY BD8	NPY BD2 - BD1	NPY BD8 - BD7
		Low Stress		High Stress		Stress Change	
AGILITY	PreAgility	-0.049	-0.159	-0.302	-0.255	-0.302	-0.25
	PostAgility	-0.093	-0.154	-0.291	-0.226	-0.289	-0.222
AEROBIC POWER	VO2MaxB	-0.149	-0.060	0.323	0.188	0.334	0.192
	VO2MaxP	-0.151	-0.137	0.312	0.262	0.323	0.27
MUSCLE ENDURANCE	PrePushups	0.003	0.086	0.271	0.225	0.274	0.223
	PostPushups	0.021	0.115	0.296	0.255	0.298	0.252
	PreModPullUp	0.041	0.125	0.328	0.256	0.329	0.253
	PostModPullUp	0.077	0.098	0.317	0.263	0.316	0.261
CORE ENDURANCE	PreSitups	-0.034	0.057	0.321	0.19	0.326	0.189
	PostSitups	0.022	0.054	0.321	0.223	0.323	0.223
	PreSupBridgeR	0.029	0.103	0.31	0.279	0.311	0.277
	PostSupBridgeR	0.088	0.023	0.323	0.267	0.322	0.269
	PreSupBridgeL	0.051	0.131	0.329	0.3	0.33	0.297
	PostSupBridgeL	0.21	0.163	0.354	0.298	0.346	0.293
	PreSupBridgeRL	0.041	0.121	0.33	0.299	0.331	0.296
	PostSupBridgeRL	0.155	0.097	0.347	0.29	0.342	0.288
	PreLatBridgeR	0.065	0.086	0.423	0.377	0.424	0.377
	PostLatBridgeR	0.069	0.020	0.368	0.304	0.368	0.306
	PreLatBridgeL	0.024	0.037	0.423	0.339	0.425	0.341
	PostLatBridgeL	-0.008	-0.035	0.369	0.285	0.373	0.289
	PreLatBridgeRL	0.046	0.064	0.44	0.372	0.442	0.373
	PostLatBridgeRL	0.031	-0.008	0.381	0.304	0.383	0.308

Table 24. Pearson Correlation Results. NPY levels compared to Anaerobic Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. NPY levels were associated with very few aspects of Anaerobic Physical Performance.

		NPY					
		NPY BD1	NPY BD7	NPY BD2	NPY BD8	NPY BD2 - BD1	NPY BD8 - BD7
		Low Stress		High Stress		Stress Change	
ANAEROBIC POWER	PreRolePullR	0.025	-0.114	-0.069	-0.043	-0.070	-0.038
	PostRolePullR	0.056	-0.065	-0.101	-0.049	-0.105	-0.047
	PreRolePullL	0.035	-0.099	-0.030	-0.038	-0.032	-0.034
	PostRolePullL	0.014	-0.093	-0.071	-0.036	-0.072	-0.032
	PreRolePullRL	0.031	-0.108	-0.050	-0.041	-0.052	-0.037
	PostRolePullRL	0.036	-0.082	-0.088	-0.043	-0.090	-0.040
	PreLongJump	0.042	0.103	0.216	0.158	0.216	0.155
	PostLongJump	0.044	0.048	0.251	0.197	0.251	0.197
	PreRotSBTossR	0.020	0.030	0.061	0.013	0.060	0.012
	PostRotSBTossR	0.030	0.018	0.054	0.020	0.053	0.020
	PreRotSBTossL	-0.001	0.013	0.034	0.018	0.034	0.017
	PostRotSBTossL	0.020	0.016	0.049	0.029	0.049	0.029
	PreRotSBTossRL	0.010	0.022	0.048	0.015	0.048	0.014
	PostRotSBTossRL	0.025	0.017	0.052	0.025	0.052	0.024
	PreSledPushPull	-0.040	-0.074	-0.128	-0.074	-0.127	-0.071
	PostSledPushPull	-0.142	-0.115	-0.161	-0.100	-0.155	-0.096
	PreUpperWingatePeakW	0.052	0.059	0.002	0.001	-0.001	-0.002
	PostUpperWingatePeakW	0.077	0.097	-0.038	-0.027	-0.043	-0.032
	PreUpperWingatePeakWkg	0.003	0.040	0.107	0.078	0.108	0.076
	PostUpperWingatePeakWkg	0.027	0.083	0.072	0.048	0.072	0.045
	PreUpperWingateAvgW	0.049	0.067	0.032	0.019	0.030	0.016
	PostUpperWingateAvgW	0.077	0.080	-0.008	0.001	-0.012	-0.003
	PreUpperWingateAvgWkg	-0.004	0.051	0.147	0.104	0.149	0.103
	PostUpperWingateAvgWkg	0.026	0.061	0.122	0.097	0.122	0.095
	PreLowerWingatePeakW	0.027	0.043	0.062	-0.001	0.061	-0.003
	PostLowerWingatePeakW	0.159	0.129	0.037	0.040	0.029	0.034
	PreLowerWingatePeakWkg	-0.050	0.006	0.232	0.154	0.237	0.155

	PostLowerWingatePeakWkg	0.139	0.155	0.251	0.21	0.246	0.205
	PreLowerWingateAvgW	0.021	0.047	0.085	0.029	0.085	0.027
	PostLowerWingateAvgW	0.153	0.138	0.085	0.086	0.078	0.081
	PreLowerWingateAvgWkg	-0.013	0.009	0.262	0.179	0.266	0.180
	PostLowerWingateAvgWkg	0.131	0.164	0.315	0.275	0.312	0.27

Table 25. Pearson Correlation Results. NPY levels compared to Balance Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association.

		NPY					
		NPY BD1	NPY BD7	NPY BD2	NPY BD8	NPY BD2 - BD1	NPY BD8 - BD7
		Low Stress		High Stress		Stress Change	
BALANCE	PreUpperYBTMedR	0.102	0.063	0.140	0.083	0.136	0.081
	PostUpperYBTMedR	0.035	0.033	0.114	0.053	0.113	0.053
	PreUpperYBTILR	0.159	0.118	0.173	0.135	0.167	0.131
	PostUpperYBTILR	0.130	0.064	0.157	0.057	0.151	0.055
	PreUpperYBTSLR	0.067	-0.001	0.214	0.279	0.212	0.282
	PostUpperYBTSLR	0.057	0.024	0.233	0.273	0.232	0.275
	PreUpperYBTMedL	0.079	-0.013	0.136	0.061	0.133	0.062
	PostUpperYBTMedL	0.059	0.048	0.042	0.018	0.039	0.016
	PreUpperYBTILL	0.066	0.045	0.113	0.048	0.110	0.047
	PostUpperYBTILL	0.075	0.042	0.092	0.003	0.089	0.001
	PreUpperYBTSLL	0.001	-0.035	0.192	0.259	0.193	0.262
	PostUpperYBTSLL	0.014	-0.009	0.193	0.256	0.194	0.259
	PreUpperYBTCOMR	0.086	0.068	0.256	0.2	0.254	0.199
	PostUpperYBTCOMR	0.046	0.046	0.256	0.156	0.256	0.155
	PreUpperYBTCOML	0.011	-0.004	0.214	0.148	0.216	0.149
	PostUpperYBTCOML	0.016	0.031	0.191	0.121	0.192	0.121
	PreUpperYBTRL	0.050	0.031	0.24	0.179	0.24	0.179
	PostUpperYBTRL	0.032	0.040	0.231	0.145	0.232	0.144
	PreLowerYBTAntR	-0.034	-0.007	-0.022	0.034	-0.021	0.035
	PostLowerYBTAntR	0.004	0.012	0.071	0.032	0.072	0.031
	PreLowerYBTAntL	-0.102	-0.066	0.036	0.037	0.042	0.040
	PostLowerYBTAntL	-0.039	-0.052	0.121	0.118	0.124	0.121
	PreLowerYBTPMR	0.031	0.003	0.130	0.125	0.130	0.126
	PostLowerYBTPMR	-0.024	-0.020	0.097	0.082	0.099	0.084
	PreLowerYBTPML	0.003	0.033	0.147	0.126	0.149	0.126
	PostLowerYBTPML	-0.039	-0.046	0.064	0.088	0.067	0.091
	PreLowerYBTPLR	0.010	0.050	0.091	0.136	0.092	0.135

	PostLowerYBTPLR	0.027	0.059	0.106	0.127	0.106	0.125
	PreLowerYBTPLL	0.023	0.011	0.078	0.111	0.078	0.112
	PostLowerYBTPLL	0.009	-0.001	0.079	0.097	0.079	0.098
	PreLowerYBTCOMR	-0.020	0.020	0.184	0.193	0.187	0.194
	PostLowerYBTCOMR	-0.021	0.022	0.209	0.172	0.213	0.173
	PreLowerYBTCOML	-0.053	-0.001	0.202	0.186	0.207	0.188
	PostLowerYBTCOML	-0.065	-0.030	0.204	0.193	0.21	0.196
	PreLowerYBTRL	-0.034	0.007	0.199	0.194	0.203	0.196
	PostLowerYBTRL	-0.046	-0.007	0.211	0.188	0.215	0.19

Table 26. Pearson Correlation Results. Serotonin levels compared to Anthropometric and Cardiac Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Resting serotonin was associated with lower systolic pressure.

		SEROTONIN					
		SERO BD1	SERO BD7	SERO BD2	SERO BD8	SERO BD2 - BD1	SERO BD8 - BD7
		Low Stress		High Stress		Stress Change	
ANTHRO-POMETRICS	WeightB	0.030	0.093	-0.013	-0.004	-0.051	-0.116
	WeightP	0.033	0.095	-0.004	0.002	-0.042	-0.111
	BodyFatB	-0.098	-0.088	-0.076	-0.096	-0.002	-0.032
	BodyFatP	-0.089	-0.094	-0.068	-0.088	0.000	-0.012
	PreAbCir	0.010	0.073	0.001	-0.028	-0.009	-0.126
	PostAbCir	0.031	0.093	-0.005	0.001	-0.041	-0.109
	LMMB	0.076	0.123	0.029	0.044	-0.041	-0.084
	LMMP	0.073	0.127	0.026	0.044	-0.043	-0.090
CARDIAC	PreRestingHR	0.058	0.041	0.056	0.084	0.018	0.070
	PostRestingHR	0.082	0.018	0.121	0.104	0.084	0.126
	PreSystolic	0.248	0.291	0.116	0.203	-0.103	-0.058
	PostSystolic	0.213	0.181	0.078	0.050	-0.120	-0.144
	PreDiastolic	0.129	0.123	0.056	0.070	-0.059	-0.047
	PostDiastolic	0.040	0.077	0.004	-0.061	-0.037	-0.177

Table 27. Pearson Correlation Results. Serotonin levels compared to Agility, Aerobic Power, Muscle Endurance, and Core Endurance Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Resting serotonin was weakly associated with better post-testing Agility and Sit-up scores.

		SEROTONIN					
		SERO BD1	SERO BD7	SERO BD2	SERO BD8	SERO BD2 - BD1	SERO BD8 - BD7
		Low Stress		High Stress		Stress Change	
AGILITY	PreAgility	-0.176	-0.159	-0.145	-0.151	-0.016	-0.024
	PostAgility	-0.228	-0.194	-0.177	-0.188	-0.004	-0.035
AEROBIC POWER	VO2MaxB	0.114	0.023	0.120	0.069	0.048	0.070
	VO2MaxP	0.165	0.077	0.123	0.074	-0.003	0.013
MUSCLE ENDURANCE	PrePushups	0.154	0.173	0.140	0.103	0.033	-0.060
	PostPushups	0.166	0.202	0.132	0.132	0.009	-0.053
	PreModPullUp	0.128	0.133	0.123	0.004	0.037	-0.153
	PostModPullUp	0.128	0.177	0.142	0.093	0.064	-0.079
CORE ENDURANCE	PreSitups	0.183	0.152	0.108	0.058	-0.044	-0.098
	PostSitups	0.201	0.194	0.138	0.079	-0.022	-0.119
	PreSupBridgeR	0.058	0.021	0.106	-0.001	0.089	-0.026
	PostSupBridgeR	0.070	0.059	0.084	0.000	0.044	-0.070
	PreSupBridgeL	0.081	0.032	0.139	0.046	0.110	0.027
	PostSupBridgeL	-0.002	0.009	0.028	-0.048	0.042	-0.078
	PreSupBridgeRL	0.072	0.027	0.126	0.023	0.103	0.000
	PostSupBridgeRL	0.033	0.034	0.056	-0.025	0.044	-0.076
	PreLatBridgeR	0.115	0.081	0.2	0.108	0.161	0.057
	PostLatBridgeR	0.044	0.047	0.082	0.049	0.069	0.013
	PreLatBridgeL	0.100	0.042	0.141	0.075	0.093	0.056
	PostLatBridgeL	0.015	0.002	0.073	0.012	0.088	0.015
	PreLatBridgeRL	0.112	0.064	0.177	0.095	0.132	0.059
	PostLatBridgeRL	0.030	0.025	0.080	0.031	0.081	0.015

Table 28. Pearson Correlation Results. Serotonin levels compared to Anaerobic Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Pre- and post-testing resting serotonin levels were associated with better scores for nearly every aspect of Anaerobic Physical Performance.

		SEROTONIN					
		SERO BD1	SERO BD7	SERO BD2	SERO BD8	SERO BD2 - BD1	SERO BD8 - BD7
		Low Stress		High Stress		Stress Change	
ANAEROBIC POWER	PreRolePullR	-0.22	-0.196	-0.143	-0.161	0.035	0.005
	PostRolePullR	-0.206	-0.235	-0.169	-0.164	-0.017	0.046
	PreRolePullL	-0.236	-0.227	-0.165	-0.167	0.020	0.034
	PostRolePullL	-0.163	-0.192	-0.170	-0.135	-0.067	0.038
	PreRolePullRL	-0.233	-0.216	-0.157	-0.167	0.027	0.020
	PostRolePullRL	-0.188	-0.218	-0.174	-0.153	-0.044	0.043
	PreLongJump	0.258	0.235	0.193	0.157	-0.004	-0.057
	PostLongJump	0.22	0.201	0.203	0.129	0.052	-0.057
	PreRotSBTossR	0.276	0.245	0.194	0.152	-0.023	-0.077
	PostRotSBTossR	0.236	0.228	0.160	0.110	-0.027	-0.116
	PreRotSBTossL	0.264	0.234	0.166	0.123	-0.049	-0.103
	PostRotSBTossL	0.211	0.216	0.145	0.102	-0.022	-0.113
	PreRotSBTossRL	0.272	0.242	0.182	0.139	-0.036	-0.090
	PostRotSBTossRL	0.225	0.224	0.154	0.107	-0.024	-0.115
	PreSledPushPull	-0.235	-0.228	-0.197	-0.166	-0.026	0.037
	PostSledPushPull	-0.208	-0.216	-0.179	-0.173	-0.029	0.012
	PreUpperWingatePeakW	0.169	0.23	0.128	0.093	0.001	-0.146
	PostUpperWingatePeakW	0.128	0.164	0.074	0.071	-0.034	-0.096
	PreUpperWingatePeakWkg	0.183	0.221	0.148	0.083	0.016	-0.149
	PostUpperWingatePeakWkg	0.137	0.155	0.088	0.071	-0.023	-0.086
	PreUpperWingateAvgW	0.154	0.234	0.129	0.093	0.019	-0.151
	PostUpperWingateAvgW	0.122	0.169	0.095	0.078	0.004	-0.092
	PreUpperWingateAvgWkg	0.162	0.221	0.148	0.085	0.039	-0.146
	PostUpperWingateAvgWkg	0.131	0.161	0.116	0.083	0.023	-0.077
	PreLowerWingatePeakW	0.150	0.138	0.069	0.039	-0.049	-0.093
	PostLowerWingatePeakW	0.234	0.213	0.162	0.144	-0.022	-0.052
	PreLowerWingatePeakWkg	0.137	0.086	0.056	0.036	-0.054	-0.042

	PostLowerWingatePeakWkg	0.254	0.182	0.176	0.128	-0.022	-0.037
	PreLowerWingateAvgW	0.153	0.120	0.070	0.039	-0.050	-0.074
	PostLowerWingateAvgW	0.218	0.203	0.168	0.144	0.004	-0.040
	PreLowerWingateAvgWkg	0.166	0.093	0.067	0.075	-0.068	0.005
	PostLowerWingateAvgWkg	0.217	0.156	0.173	0.119	0.013	-0.019

Table 29. Pearson Correlation Results. Serotonin levels compared to Balance Physical Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Serotonin was associated with very few aspects of Balance.

		SEROTONIN					
		SERO BD1	SERO BD7	SERO BD2	SERO BD8	SERO BD2 - BD1	SERO BD8 - BD7
		Low Stress		High Stress		Stress Change	
BALANCE	PreUpperYBTMedR	0.144	0.072	0.079	0.025	-0.044	-0.050
	PostUpperYBTMedR	0.188	0.115	0.085	0.083	-0.083	-0.019
	PreUpperYBTILR	0.043	-0.012	0.045	0.043	0.018	0.075
	PostUpperYBTILR	0.116	0.116	0.125	0.076	0.054	-0.030
	PreUpperYBTSLR	0.217	0.146	0.208	0.128	0.062	0.008
	PostUpperYBTSLR	0.244	0.151	0.227	0.166	0.059	0.055
	PreUpperYBTMedL	0.148	0.110	0.038	0.045	-0.107	-0.067
	PostUpperYBTMedL	0.140	0.098	0.074	0.072	-0.047	-0.015
	PreUpperYBTILL	0.104	0.054	0.082	0.064	0.003	0.027
	PostUpperYBTILL	0.130	0.133	0.090	0.083	-0.012	-0.042
	PreUpperYBTSLL	0.22	0.112	0.161	0.080	-0.008	-0.019
	PostUpperYBTSLL	0.216	0.135	0.202	0.136	0.055	0.033
	PreUpperYBTCOMR	0.125	0.020	0.081	0.041	-0.020	0.034
	PostUpperYBTCOMR	0.198	0.108	0.137	0.104	-0.019	0.018
	PreUpperYBTCOML	0.154	0.052	0.063	0.039	-0.077	-0.007
	PostUpperYBTCOML	0.185	0.111	0.110	0.096	-0.043	0.004
	PreUpperYBTRL	0.147	0.037	0.079	0.044	-0.047	0.019
	PostUpperYBTRL	0.197	0.109	0.125	0.097	-0.035	0.007
	PreLowerYBTAntR	-0.025	-0.089	-0.016	-0.085	0.005	-0.014
	PostLowerYBTAntR	0.034	-0.081	-0.028	-0.075	-0.078	-0.009
	PreLowerYBTAntL	-0.001	0.005	-0.023	-0.095	-0.032	-0.140
	PostLowerYBTAntL	0.053	-0.014	0.065	0.006	0.036	0.024
	PreLowerYBTPMR	0.160	0.174	0.135	0.115	0.020	-0.045
	PostLowerYBTPMR	0.078	0.091	0.082	0.046	0.033	-0.043
	PreLowerYBTPML	0.096	0.141	0.121	0.085	0.070	-0.047
	PostLowerYBTPML	0.127	0.118	0.089	0.094	-0.012	-0.007
	PreLowerYBTPLR	0.073	0.143	0.080	0.134	0.035	0.020

	PostLowerYBTPLR	0.138	0.139	0.131	0.116	0.039	-0.002
	PreLowerYBTPLL	0.131	0.195	0.144	0.164	0.064	0.000
	PostLowerYBTPLL	0.107	0.102	0.066	0.099	-0.021	0.019
	PreLowerYBTCOMR	0.013	0.035	0.084	0.079	0.106	0.070
	PostLowerYBTCOMR	0.005	-0.020	0.066	0.036	0.089	0.075
	PreLowerYBTCOML	0.010	0.070	0.103	0.073	0.137	0.020
	PostLowerYBTCOML	0.026	0.002	0.084	0.083	0.092	0.115
	PreLowerYBTRL	0.008	0.051	0.096	0.076	0.129	0.047
	PostLowerYBTRL	0.021	-0.005	0.080	0.064	0.091	0.096

Table 30. Pearson Correlation Results. Cortisol levels compared to Executive Function and Fluid Intelligence Cognitive Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Cortisol tended to be negatively correlated with reaction time (faster responses) and had mixed effects on test accuracy for aspects of both the Executive Function and Fluid Intelligence tasks.

		CORTISOL					
		CORT BD1	CORT BD7	CORT BD3	CORT BD9	CORT BD3 - BD1	CORT BD9 - BD7
		Low Stress		High Stress		Stress Change	
EXECUTIVE FUNCTION	SDMTB	0.058	0.178	0.012	0.146	0.039	-0.088
	SDMTP	0.172	0.223	0.157	0.200	-0.016	-0.067
	PreKeepTrackWordsRecalled	0.182	0.295	0.278	0.182	0.182	0.058
	PreKeepTrackMeanRT	-0.072	-0.116	-0.050	-0.053	0.037	0.126
	PreKeepTrackMeanAccRT	-0.030	-0.112	0.114	-0.192	0.160	0.060
	PostKeepTrackWordsRecalled	0.092	0.090	0.209	0.074	0.172	0.120
	PostKeepTrackMeanRT	-0.065	-0.088	-0.109	-0.029	-0.016	0.061
	PostKeepTrackMeanAccRT	-0.005	0.044	0.095	0.121	-0.001	-0.053
	PreStroopCongruousRT	-0.251	-0.170	-0.179	-0.127	-0.137	-0.142
	PreStroopCongruousAcc	-0.116	-0.207	-0.291	-0.187	-0.055	-0.033
	PreStroopIncongruousRT	-0.259	-0.154	-0.236	-0.099	-0.080	-0.084
	PreStroopIncongruousAcc	-0.122	0.085	0.013	0.028	0.102	-0.052
	PreStroopEffect	-0.175	-0.070	-0.229	-0.019	0.036	0.036
	PreStroopCost	-0.104	0.027	-0.185	0.047	-0.019	-0.003
	PreStroopBenefit	-0.199	-0.272	-0.128	-0.182	0.163	0.116
	PostStroopCongruousRT	-0.183	-0.249	-0.122	-0.023	-0.095	-0.095
	PostStroopCongruousAcc	0.010	-0.086	0.053	0.038	0.100	0.031
	PostStroopIncongruousRT	-0.093	-0.254	-0.032	0.089	-0.021	-0.036
	PostStroopIncongruousAcc	0.016	-0.047	0.138	0.052	0.122	0.027
	PostStroopEffect	0.023	-0.186	0.068	0.179	0.081	0.052
	PostStroopCost	0.033	-0.176	0.114	0.175	0.073	0.068
	PostStroopBenefit	-0.044	0.054	-0.187	-0.073	0.006	-0.062
FLUID INTELLIGENCE	PreNumberSeriesCorrectTrials	-0.016	0.025	0.100	0.021	0.038	0.078
	PreNumberSeriesCorrectTrialRT	0.125	0.128	-0.158	0.014	-0.162	-0.210
	PostNumberSeriesCorrectTrials	0.130	0.036	0.240	0.142	0.096	0.125
	PostNumberSeriesCorrectTrialRT	-0.322	-0.222	-0.277	-0.217	-0.015	0.061
	PreLetterSetsCorrectTrials	0.159	0.225	0.134	0.168	-0.033	0.077

	PreLetterSetsCorrectTrialRT	-0.143	0.047	-0.071	-0.042	-0.015	-0.122
	PostLetterSetsCorrectTrials	0.097	0.310	0.350	0.263	0.164	0.094
	PostLetterSetsCorrectTrialRT	0.032	-0.020	0.055	-0.031	0.056	0.090

Table 31. Pearson Correlation Results. Cortisol levels compared to Working Memory and Episodic Memory Cognitive Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Cortisol tended to be negatively associated with the Free Recall Episodic Memory tasks, but had mixed effects on Working Memory tasks.

		CORTISOL					
		CORT BD1	CORT BD7	CORT BD3	CORT BD9	CORT BD3 - BD1	CORT BD9 - BD7
		Low Stress		High Stress		Stress Change	
WORKING MEMORY	PreRotationSpanTotal	-0.094	0.082	0.107	0.049	0.131	-0.007
	PreRotationSpanAbsoluteScore	-0.047	-0.026	0.032	-0.018	0.105	-0.010
	PreRotationSpanRotationErrors	0.179	-0.162	-0.208	-0.103	-0.213	-0.075
	PreRotationSpanSpeedErrors	0.042	-0.206	-0.290	-0.222	-0.198	-0.052
	PreRotationSpanAccuracyErrors	0.279	0.023	0.078	0.166	-0.112	-0.072
	PostRotationSpanTotal	-0.032	-0.065	0.165	0.048	0.078	-0.016
	PostRotationSpanAbsoluteScore	0.089	-0.132	0.035	0.002	-0.144	-0.083
	PostRotationSpanRotationErrors	0.035	-0.155	-0.238	-0.055	-0.168	-0.144
	PostRotationSpanSpeedErrors	-0.064	-0.073	-0.332	-0.128	-0.181	-0.191
	PostRotationSpanAccuracyErrors	0.168	-0.177	0.071	0.065	-0.019	0.078
	PreSymmetrySpanTotal	0.063	0.223	0.170	0.128	0.156	0.039
	PreSymmetrySpanAbsoluteScore	-0.068	0.121	0.045	0.000	0.145	-0.002
	PreSymmetrySpanSymmetryErrors	-0.112	-0.020	-0.088	-0.181	-0.127	-0.269
	PreSymmetrySpanSpeedErrors	-0.045	0.009	0.006	0.052	-0.030	-0.087
	PreSymmetrySpanAccuracyErrors	-0.107	-0.027	-0.104	-0.230	-0.126	-0.259
	PostSymmetrySpanTotal	0.081	0.153	0.236	0.329	0.130	0.090
	PostSymmetrySpanAbsoluteScore	0.143	0.042	0.224	0.212	0.157	0.116
	PostSymmetrySpanSymmetryErrors	-0.190	-0.024	-0.136	-0.233	-0.082	-0.205
	PostSymmetrySpanSpeedErrors	0.099	0.130	0.154	-0.017	0.071	-0.078
	PostSymmetrySpanAccuracyErrors	-0.261	-0.082	-0.224	-0.256	-0.129	-0.193
EPISODIC MEMORY	PreIFR_WordsWordsRecalled	0.166	0.018	0.013	0.014	-0.119	0.011
	PostIFR_WordsWordsRecalled	0.205	0.099	0.344	0.222	0.022	0.054
	PreIFR_PicturesWordsRecalled	0.263	0.163	0.221	0.221	0.072	0.114
	PostIFR_PicturesWordsRecalled	0.103	0.108	0.124	0.045	0.036	-0.019
	PrePairedAssociatesWordsRecalled	0.136	0.105	0.005	0.092	-0.115	0.000
	PostPairedAssociatesWordsRecalled	0.102	-0.002	-0.038	0.112	-0.077	0.161
	PrePairedAssociatesDelayWordsRecalled	0.163	0.096	-0.027	0.055	-0.085	0.000

	PostPairedAssociatesDelayWordsRecalled	0.107	0.052	-0.042	0.148	-0.101	0.151

Table 32. Pearson Correlation Results. DHEA-S levels compared to Executive Function and Fluid Intelligence Cognitive Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Resting DHEA-S tended to be positively correlated with the Keep Track Executive Function tasks and some aspects of Fluid Intelligence tasks.

		DHEA-S					
		DHEAS BD1	DHEAS BD7	DHEAS BD3	DHEAS BD9	DHEAS BD3 - BD1	DHEAS BD9 - BD7
		Low Stress		High Stress		Stress Change	
EXECUTIVE FUNCTION	SDMTB	-0.049	-0.067	-0.065	0.100	-0.031	0.208
	SDMTP	-0.075	-0.022	-0.126	-0.001	0.072	0.173
	PreKeepTrackWordsRecalled	0.248	0.259	0.112	0.149	0.035	0.020
	PreKeepTrackMeanRT	-0.138	-0.145	-0.014	-0.090	-0.021	-0.087
	PreKeepTrackMeanAccRT	0.206	0.185	0.167	-0.015	-0.015	-0.249
	PostKeepTrackWordsRecalled	0.261	0.297	0.059	0.121	0.074	0.061
	PostKeepTrackMeanRT	-0.039	-0.005	0.159	0.028	0.048	-0.187
	PostKeepTrackMeanAccRT	-0.177	-0.205	-0.149	-0.216	-0.056	-0.049
	PreStroopCongruousRT	-0.036	0.055	-0.062	0.033	0.132	0.124
	PreStroopCongruousAcc	-0.008	0.110	-0.091	0.017	0.175	0.147
	PreStroopIncongruousRT	0.073	0.062	0.058	0.088	-0.011	0.024
	PreStroopIncongruousAcc	0.003	-0.012	-0.085	0.026	-0.023	0.149
	PreStroopEffect	0.196	0.045	0.202	0.128	-0.207	-0.127
	PreStroopCost	0.175	0.063	0.187	0.104	-0.152	-0.136
	PreStroopBenefit	0.069	-0.043	0.054	0.073	-0.160	0.012
	PostStroopCongruousRT	0.004	0.058	0.038	0.028	0.081	-0.019
	PostStroopCongruousAcc	0.058	0.074	0.086	0.066	0.028	-0.041
	PostStroopIncongruousRT	0.050	0.033	0.082	0.006	-0.022	-0.107
	PostStroopIncongruousAcc	0.040	0.104	0.113	0.121	0.097	-0.014
	PostStroopEffect	0.081	-0.001	0.103	-0.018	-0.115	-0.164
	PostStroopCost	0.108	0.052	0.133	0.029	-0.075	-0.150
	PostStroopBenefit	-0.129	-0.171	-0.152	-0.144	-0.073	0.039
FLUID INTELLIGENCE	PreNumberSeriesCorrectTrials	0.162	0.179	0.157	0.322	0.038	0.164
	PreNumberSeriesCorrectTrialRT	0.113	0.175	0.096	0.151	0.101	0.046
	PostNumberSeriesCorrectTrials	0.202	0.221	0.115	0.113	0.044	-0.025
	PostNumberSeriesCorrectTrialRT	-0.015	-0.101	-0.199	-0.130	-0.128	0.122
	PreLetterSetsCorrectTrials	0.189	0.226	0.067	0.105	0.070	0.032

	PreLetterSetsCorrectTrialRT	-0.098	-0.008	-0.004	0.063	0.126	0.080
	PostLetterSetsCorrectTrials	0.031	0.200	0.157	0.174	0.253	-0.012
	PostLetterSetsCorrectTrialRT	0.245	0.106	0.287	0.143	-0.186	-0.229

Table 33. Pearson Correlation Results. DHEA-S levels compared to Working Memory and Episodic Memory Cognitive Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. DHEA-S tended to be positively associated with better scores on the Free Recall Episodic Memory tasks, but had mixed effects on Working Memory tasks.

		DHEA-S					
		DHEAS BD1	DHEAS BD7	DHEAS BD3	DHEAS BD9	DHEAS BD3 - BD1	DHEAS BD9 - BD7
		Low Stress		High Stress		Stress Change	
WORKING MEMORY	PreRotationSpanTotal	-0.061	-0.147	-0.002	0.035	-0.132	0.043
	PreRotationSpanAbsoluteScore	0.052	0.015	-0.004	-0.050	-0.051	-0.055
	PreRotationSpanRotationErrors	-0.178	0.048	-0.078	-0.001	0.320	0.107
	PreRotationSpanSpeedErrors	-0.063	0.046	-0.051	0.070	0.157	0.154
	PreRotationSpanAccuracyErrors	-0.209	0.021	-0.064	-0.085	0.325	-0.012
	PostRotationSpanTotal	0.155	0.138	0.203	0.208	-0.013	-0.035
	PostRotationSpanAbsoluteScore	0.029	0.101	0.286	0.137	0.109	-0.235
	PostRotationSpanRotationErrors	-0.054	0.086	0.015	-0.041	0.203	-0.070
	PostRotationSpanSpeedErrors	0.003	0.073	0.058	-0.004	0.104	-0.085
	PostRotationSpanAccuracyErrors	-0.096	0.054	-0.049	-0.066	0.215	-0.011
	PreSymmetrySpanTotal	0.050	0.158	0.071	0.170	0.163	0.103
	PreSymmetrySpanAbsoluteScore	0.021	0.070	0.057	0.174	0.075	0.127
	PreSymmetrySpanSymmetryErrors	0.022	0.057	0.059	0.004	0.054	-0.076
	PreSymmetrySpanSpeedErrors	0.018	0.015	0.035	0.015	-0.003	-0.031
	PreSymmetrySpanAccuracyErrors	0.016	0.059	0.050	-0.003	0.065	-0.073
	PostSymmetrySpanTotal	-0.171	-0.116	-0.119	0.024	0.068	0.193
	PostSymmetrySpanAbsoluteScore	-0.196	-0.074	-0.096	0.007	0.164	0.142
	PostSymmetrySpanSymmetryErrors	0.154	0.178	0.112	0.140	0.048	0.011
	PostSymmetrySpanSpeedErrors	0.234	0.244	0.336	0.268	0.033	-0.148
	PostSymmetrySpanAccuracyErrors	0.069	0.091	-0.022	0.038	0.038	0.076
EPISODIC MEMORY	PreIFR_WordsWordsRecalled	0.243	0.200	-0.057	0.068	-0.046	0.159
	PostIFR_WordsWordsRecalled	0.153	0.293	0.026	0.123	0.219	0.110
	PreIFR_PicturesWordsRecalled	0.065	0.088	-0.001	0.057	0.040	0.069
	PostIFR_PicturesWordsRecalled	-0.022	0.046	-0.061	0.016	0.099	0.103
	PrePairedAssociatesWordsRecalled	0.005	0.060	0.047	0.219	0.082	0.194
	PostPairedAssociatesWordsRecalled	-0.049	0.033	-0.080	0.101	0.118	0.229
	PrePairedAssociatesDelayWordsRecalled	0.041	0.104	0.073	0.217	0.097	0.156

	PostPairedAssociatesDelayWordsRecalled	-0.045	0.068	-0.055	0.120	0.164	0.218

Table 34. Pearson Correlation Results. NE levels compared to Executive Function and Fluid Intelligence Cognitive Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. NE was associated with few aspects of Executive Function and Fluid Intelligence.

		NOREPINEPHRINE					
		NE BD1	NE BD7	NE BD2	NE BD8	NE BD2 - BD1	NE BD8 - BD7
		Low Stress		High Stress		Stress Change	
EXECUTIVE FUNCTION	SDMTB	-0.005	-0.023	0.092	0.139	0.094	0.143
	SDMTP	-0.058	-0.100	0.051	0.085	0.059	0.098
	PreKeepTrackWordsRecalled	-0.131	-0.172	0.020	-0.081	0.038	-0.060
	PreKeepTrackMeanRT	0.036	-0.021	0.112	0.283	0.108	0.290
	PreKeepTrackMeanAccRT	0.035	-0.004	0.076	-0.031	0.073	-0.031
	PostKeepTrackWordsRecalled	-0.116	-0.065	0.089	0.029	0.106	0.038
	PostKeepTrackMeanRT	-0.046	0.036	0.048	0.229	0.055	0.226
	PostKeepTrackMeanAccRT	-0.105	-0.047	-0.054	0.073	-0.040	0.080
	PreStroopCongruousRT	0.008	0.165	-0.060	-0.114	-0.062	-0.137
	PreStroopCongruousAcc	0.067	0.158	-0.137	-0.085	-0.147	-0.107
	PreStroopIncongruousRT	0.006	0.173	-0.147	-0.109	-0.149	-0.133
	PreStroopIncongruousAcc	0.063	-0.004	-0.085	-0.094	-0.094	-0.094
	PreStroopEffect	0.001	0.102	-0.198	-0.051	-0.201	-0.064
	PreStroopCost	-0.011	0.122	-0.197	-0.048	-0.198	-0.065
	PreStroopBenefit	0.033	-0.055	-0.007	-0.008	-0.012	-0.001
	PostStroopCongruousRT	0.064	0.153	-0.047	-0.074	-0.056	-0.095
	PostStroopCongruousAcc	-0.119	0.054	-0.002	0.089	0.014	0.083
	PostStroopIncongruousRT	0.073	0.228	-0.064	0.028	-0.074	-0.001
	PostStroopIncongruousAcc	-0.132	0.017	0.052	0.097	0.070	0.096
	PostStroopEffect	0.057	0.236	-0.061	0.146	-0.070	0.117
	PostStroopCost	-0.002	0.170	-0.099	0.114	-0.100	0.093
	PostStroopBenefit	0.167	0.144	0.131	0.063	0.110	0.046
FLUID INTELLIGENCE	PreNumberSeriesCorrectTrials	-0.056	-0.049	0.150	0.071	0.159	0.078
	PreNumberSeriesCorrectTrialRT	0.173	-0.015	0.022	-0.054	-0.001	-0.053
	PostNumberSeriesCorrectTrials	-0.060	-0.126	0.069	0.031	0.078	0.047
	PostNumberSeriesCorrectTrialRT	0.121	0.014	0.060	0.077	0.044	0.076
	PreLetterSetsCorrectTrials	-0.094	-0.279	0.066	0.012	0.079	0.048
	PreLetterSetsCorrectTrialRT	0.009	0.074	0.076	0.032	0.076	0.023

	PostLetterSetsCorrectTrials	-0.133	-0.135	0.108	0.012	0.127	0.029
	PostLetterSetsCorrectTrialRT	0.021	-0.020	-0.029	0.122	-0.032	0.126

Table 35. Pearson Correlation Results. NE levels compared to Working Memory and Episodic Memory Cognitive Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. NE was associated with few aspects of Working Memory but high stress NE was negatively associated with Episodic Memory task scores.

		NOREPINEPHRINE					
		NE BD1	NE BD7	NE BD2	NE BD8	NE BD2 - BD1	NE BD8 - BD7
		Low Stress		High Stress		Stress Change	
WORKING MEMORY	PreRotationSpanTotal	0.010	0.013	0.138	0.097	0.138	0.096
	PreRotationSpanAbsoluteScore	0.019	0.027	0.136	0.082	0.135	0.080
	PreRotationSpanRotationErrors	0.163	0.032	-0.008	-0.035	-0.030	-0.039
	PreRotationSpanSpeedErrors	0.050	0.047	-0.009	0.007	-0.015	0.001
	PreRotationSpanAccuracyErrors	0.267	-0.013	-0.003	-0.088	-0.039	-0.088
	PostRotationSpanTotal	0.068	0.092	0.034	0.169	0.026	0.159
	PostRotationSpanAbsoluteScore	0.030	0.048	0.015	0.155	0.011	0.150
	PostRotationSpanRotationErrors	0.027	-0.090	0.072	-0.029	0.069	-0.017
	PostRotationSpanSpeedErrors	0.037	-0.080	0.023	-0.048	0.019	-0.038
	PostRotationSpanAccuracyErrors	-0.020	-0.058	0.160	0.045	0.164	0.053
	PreSymmetrySpanTotal	-0.035	-0.095	0.001	-0.091	0.006	-0.080
	PreSymmetrySpanAbsoluteScore	-0.013	-0.061	-0.012	-0.047	-0.010	-0.039
	PreSymmetrySpanSymmetryErrors	-0.067	0.047	-0.130	-0.080	-0.122	-0.087
	PreSymmetrySpanSpeedErrors	0.060	0.077	-0.095	-0.060	-0.104	-0.070
	PreSymmetrySpanAccuracyErrors	-0.093	0.024	-0.107	-0.065	-0.095	-0.069
	PostSymmetrySpanTotal	0.081	-0.025	0.095	0.039	0.085	0.043
	PostSymmetrySpanAbsoluteScore	0.077	0.003	0.179	0.058	0.170	0.058
	PostSymmetrySpanSymmetryErrors	-0.117	0.041	-0.095	0.001	-0.080	-0.005
	PostSymmetrySpanSpeedErrors	-0.175	-0.098	-0.055	-0.100	-0.032	-0.089
	PostSymmetrySpanAccuracyErrors	-0.043	0.096	-0.080	0.052	-0.075	0.040
EPISODIC MEMORY	PreIFR_WordsWordsRecalled	-0.065	-0.025	-0.075	-0.030	-0.067	-0.027
	PostIFR_WordsWordsRecalled	-0.086	-0.043	-0.001	-0.026	0.011	-0.021
	PreIFR_PicturesWordsRecalled	-0.210	-0.110	-0.137	-0.065	-0.110	-0.051
	PostIFR_PicturesWordsRecalled	-0.108	-0.070	-0.075	-0.005	-0.061	0.004
	PrePairedAssociatesWordsRecalled	-0.100	-0.224	-0.253	-0.169	-0.242	-0.142
	PostPairedAssociatesWordsRecalled	-0.034	-0.083	-0.129	-0.102	-0.126	-0.093
	PrePairedAssociatesDelayWordsRecalled	-0.061	-0.102	-0.228	-0.218	-0.223	-0.207

	PostPairedAssociatesDelayWordsRecalled	-0.027	-0.116	-0.135	-0.033	-0.133	-0.018

Table 36. Pearson Correlation Results. NPY levels compared to Executive Function and Fluid Intelligence Cognitive Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. High stress NPY was positively correlated with some aspects the Keep Track Executive Function tasks and the Letter Sets Fluid Intelligence tasks.

		NPY					
		NPY	NPY BD7	NPY BD2	NPY BD8	NPY BD2 - BD1	NPY BD8 - BD7
		Low Stress		High Stress		Stress Change	
EXECUTIVE FUNCTION	SDMTB	-0.015	-0.056	0.004	-0.010	0.005	-0.008
	SDMTP	-0.064	-0.107	0.012	0.014	0.015	0.019
	PreKeepTrackWordsRecalled	0.126	0.079	.209	.223	.204	.222
	PreKeepTrackMeanRT	-0.153	-0.129	.215	0.105	.225	0.111
	PreKeepTrackMeanAccRT	0.023	0.058	-0.089	-0.076	-0.091	-0.079
	PostKeepTrackWordsRecalled	.176	.204	0.155	.212	0.148	.206
	PostKeepTrackMeanRT	-0.032	-0.134	0.127	0.042	0.129	0.048
	PostKeepTrackMeanAccRT	0.059	0.062	0.063	0.075	0.061	0.073
	PreStroopCongruousRT	-0.063	0.052	-0.093	-0.161	-0.090	-0.164
	PreStroopCongruousAcc	0.020	0.042	-0.023	-0.164	-0.025	-0.167
	PreStroopIncongruousRT	-0.045	0.014	-0.069	-0.174	-0.067	-.176
	PreStroopIncongruousAcc	.220	0.109	-0.016	-0.111	-0.028	-0.116
	PreStroopEffect	0.000	-0.046	-0.004	-0.111	-0.004	-0.110
	PreStroopCost	0.010	-0.049	0.021	-0.102	0.021	-0.101
	PreStroopBenefit	-0.029	0.007	-0.073	-0.029	-0.072	-0.029
	PostStroopCongruousRT	-.179	0.000	-0.087	-0.120	-0.079	-0.121
	PostStroopCongruousAcc	-0.039	0.022	0.055	0.030	0.057	0.030
	PostStroopIncongruousRT	-0.135	0.019	-0.020	-0.068	-0.013	-0.070
	PostStroopIncongruousAcc	0.001	0.064	0.054	0.031	0.054	0.028
	PostStroopEffect	-0.026	0.035	0.072	0.023	0.074	0.022
	PostStroopCost	-0.045	0.021	0.086	0.061	0.090	0.061
	PostStroopBenefit	0.064	0.035	-0.061	-0.123	-0.065	-0.126
FLUID INTELLIGENCE	PreNumberSeriesCorrectTrials	0.077	0.079	0.093	.194	0.089	.192
	PreNumberSeriesCorrectTrialRT	-0.029	-0.054	0.068	0.111	0.071	0.114
	PostNumberSeriesCorrectTrials	0.014	0.070	0.084	.187	0.084	.185
	PostNumberSeriesCorrectTrialRT	-0.030	0.029	-0.007	-0.132	-0.006	-0.134
	PreLetterSetsCorrectTrials	-0.028	0.039	-0.086	0.033	-0.086	0.032

	PreLetterSetsCorrectTrialRT	-0.024	0.099	.247	0.040	.250	0.036
	PostLetterSetsCorrectTrials	0.058	0.086	0.142	.216	0.140	.215
	PostLetterSetsCorrectTrialRT	0.044	0.158	0.006	0.064	0.004	0.058

Table 37. Pearson Correlation Results. NPY levels compared to Working Memory and Episodic Memory Cognitive Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. High Stress NPY was positively correlated with the Symmetry Span Executive Function task scores but not associated with Episodic Memory.

		NPY					
		NPY BD1	NPY BD7	NPY BD2	NPY BD8	NPY BD2 - BD1	NPY BD8 - BD7
		Low Stress		High Stress		Stress Change	
WORKING MEMORY	PreRotationSpanTotal	0.086	0.005	0.123	.193	0.120	.194
	PreRotationSpanAbsoluteScore	0.039	0.004	0.123	0.136	0.123	0.137
	PreRotationSpanRotationErrors	-0.161	-.227	-0.085	-0.075	-0.077	-0.066
	PreRotationSpanSpeedErrors	-0.136	-.270	-0.088	-0.114	-0.082	-0.104
	PreRotationSpanAccuracyErrors	-0.110	-0.017	-0.028	0.039	-0.023	0.040
	PostRotationSpanTotal	0.011	0.046	0.141	.203	0.142	.202
	PostRotationSpanAbsoluteScore	-0.006	0.036	0.010	0.130	0.010	0.130
	PostRotationSpanRotationErrors	-0.121	-0.161	-0.023	-0.068	-0.017	-0.062
	PostRotationSpanSpeedErrors	-0.133	-.184	-0.078	-0.136	-0.072	-0.130
	PostRotationSpanAccuracyErrors	-0.008	0.013	0.147	0.169	0.149	0.170
	PreSymmetrySpanTotal	0.079	0.131	0.073	0.155	0.069	0.151
	PreSymmetrySpanAbsoluteScore	0.111	0.041	0.067	0.143	0.062	0.142
	PreSymmetrySpanSymmetryErrors	0.157	0.053	-0.048	-0.125	-0.056	-0.129
	PreSymmetrySpanSpeedErrors	.206	.211	0.117	0.057	0.107	0.049
	PreSymmetrySpanAccuracyErrors	0.098	-0.016	-0.091	-0.154	-0.097	-0.155
	PostSymmetrySpanTotal	0.113	0.109	.235	.233	.232	.231
	PostSymmetrySpanAbsoluteScore	0.089	0.054	.233	.209	.231	.208
	PostSymmetrySpanSymmetryErrors	-0.060	-0.071	-0.164	-.203	-0.162	-.202
	PostSymmetrySpanSpeedErrors	0.020	0.040	-0.020	0.014	-0.021	0.012
	PostSymmetrySpanAccuracyErrors	-0.079	-0.101	-.176*	-.238	-.174	-.236
EPISODIC MEMORY	PreIFR_WordsWordsRecalled	-0.062	-0.075	-0.037	-0.027	-0.035	-0.024
	PostIFR_WordsWordsRecalled	0.037	-0.031	0.002	0.165	0.000	0.168
	PreIFR_PicturesWordsRecalled	-0.076	-0.005	0.118	0.054	0.123	0.055
	PostIFR_PicturesWordsRecalled	-0.093	-0.050	0.072	-0.008	0.077	-0.006
	PrePairedAssociatesWordsRecalled	-0.039	-0.043	0.002	-0.054	0.004	-0.053
	PostPairedAssociatesWordsRecalled	-0.014	0.025	0.174	.188	.176	.188
	PrePairedAssociates_DelayWordsRecalled	0.011	-0.015	-0.021	-0.004	-0.022	-0.003

	PostPairedAssociates_DelayWordsRecalled	-0.027	-0.010	0.169	0.170	0.171	0.171

Table 38. Pearson Correlation Results. Serotonin levels compared to Executive Function and Fluid Intelligence Cognitive Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Serotonin was associated with few aspects of Executive Function and Fluid Intelligence.

		SEROTONIN					
		SERO BD1	SERO BD7	SERO BD2	SERO BD8	SERO BD2 - BD1	SERO BD8 - BD7
		Low Stress		High Stress		Stress Change	
EXECUTIVE FUNCTION	SDMTB	0.103	-0.021	0.150	0.070	0.102	0.122
	SDMTP	0.135	0.103	.196	0.140	0.133	0.076
	PreKeepTrackWordsRecalled	-0.063	-0.047	-0.007	0.001	0.062	0.057
	PreKeepTrackMeanRT	0.053	0.106	-0.049	-0.083	-0.136	-.238
	PreKeepTrackMeanAccRT	-0.106	-0.012	-0.087	-0.058	-0.009	-0.065
	PostKeepTrackWordsRecalled	-0.054	0.042	0.041	0.109	0.117	0.104
	PostKeepTrackMeanRT	-0.005	0.057	-0.015	-0.139	-0.016	-.265
	PostKeepTrackMeanAccRT	-0.062	-0.005	-0.030	-0.039	0.024	-0.048
	PreStroopCongruousRT	-0.109	-0.081	-0.146	-0.170	-0.089	-0.142
	PreStroopCongruousAcc	-0.007	-0.069	-0.077	-0.111	-0.106	-0.073
	PreStroopIncongruousRT	-0.087	-0.093	-0.129	-0.143	-0.088	-0.091
	PreStroopIncongruousAcc	0.032	-0.102	-0.065	-0.151	-0.136	-0.090
	PreStroopEffect	-0.017	-0.065	-0.044	-0.040	-0.046	0.023
	PreStroopCost	-0.016	-0.051	-0.052	-0.057	-0.058	-0.018
	PreStroopBenefit	-0.001	-0.042	0.021	0.048	0.033	0.120
	PostStroopCongruousRT	0.024	0.028	-0.116	-0.058	-.193	-0.115
	PostStroopCongruousAcc	0.022	0.043	0.051	0.021	0.048	-0.022
	PostStroopIncongruousRT	0.012	0.014	-0.072	-0.072	-0.117	-0.118
	PostStroopIncongruousAcc	-0.037	-0.023	-0.008	-0.072	0.029	-0.075
	PostStroopEffect	-0.008	-0.009	0.011	-0.062	0.024	-0.077
	PostStroopCost	-0.022	-0.014	-0.034	-0.044	-0.024	-0.046
	PostStroopBenefit	0.046	0.016	0.134	-0.039	0.142	-0.075
FLUID INTELLIGENCE	PreNumberSeriesCorrectTrials	0.123	0.032	0.101	0.070	0.009	0.058
	PreNumberSeriesCorrectTrialRT	0.013	-0.047	-0.026	0.005	-0.054	0.062
	PostNumberSeriesCorrectTrials	0.120	0.096	0.087	0.082	-0.006	0.001
	PostNumberSeriesCorrectTrialRT	0.015	0.000	-0.012	-0.037	-0.033	-0.052
	PreLetterSetsCorrectTrials	0.034	0.018	0.019	0.073	-0.011	0.078

	PreLetterSetsCorrectTrialRT	-0.024	0.061	-0.035	-0.086	-0.025	-.189
	PostLetterSetsCorrectTrials	-0.040	0.031	-0.007	0.048	0.033	0.031
	PostLetterSetsCorrectTrialRT	-0.040	-0.079	-0.017	-0.105	0.019	-0.054

Table 39. Pearson Correlation Results. Serotonin levels compared to Working Memory and Episodic Memory Cognitive Performance measures. Red shaded cells indicate positive correlations and blue shaded cells indicate negative correlations. Darker shading represents stronger association. Serotonin was associated with few aspects of Working Memory and Episodic Memory.

		SEROTONIN					
		SERO BD1	SERO BD7	SERO BD2	SERO BD8	SERO BD2 - BD1	SERO BD8 - BD7
		Low Stress		High Stress		Stress Change	
WORKING MEMORY	PreRotationSpanTotal	0.064	-0.065	0.037	0.041	-0.018	0.133
	PreRotationSpanAbsoluteScore	0.084	0.015	0.056	0.098	-0.013	0.117
	PreRotationSpanRotationErrors	-0.072	-0.019	0.021	0.035	0.115	0.071
	PreRotationSpanSpeedErrors	-0.054	-0.045	0.008	0.019	0.075	0.079
	PreRotationSpanAccuracyErrors	-0.062	0.039	0.031	0.043	0.118	0.013
	PostRotationSpanTotal	0.118	0.071	0.036	0.105	-0.077	0.064
	PostRotationSpanAbsoluteScore	0.061	0.021	-0.005	0.135	-0.074	0.165
	PostRotationSpanRotationErrors	-0.001	-0.037	0.074	0.063	0.107	0.133
	PostRotationSpanSpeedErrors	0.010	-0.018	0.069	0.052	0.087	0.095
	PostRotationSpanAccuracyErrors	-0.032	-0.067	0.039	0.051	0.090	0.152
	PreSymmetrySpanTotal	0.059	0.010	0.089	0.059	0.066	0.068
	PreSymmetrySpanAbsoluteScore	0.114	0.022	0.162	0.119	0.113	0.137
	PreSymmetrySpanSymmetryErrors	-0.133	-0.105	-0.124	-0.176	-0.033	-0.119
	PreSymmetrySpanSpeedErrors	-0.054	-0.075	-0.059	-0.085	-0.026	-0.028
	PreSymmetrySpanAccuracyErrors	-0.124	-0.087	-0.113	-0.160	-0.027	-0.118
	PostSymmetrySpanTotal	0.041	0.048	0.100	0.054	0.099	0.019
	PostSymmetrySpanAbsoluteScore	0.048	0.061	0.154	0.103	0.168	0.073
	PostSymmetrySpanSymmetryErrors	-0.059	-0.114	-0.111	-0.178	-0.095	-0.116
	PostSymmetrySpanSpeedErrors	-0.022	0.013	0.056	0.017	0.104	0.009
	PostSymmetrySpanAccuracyErrors	-0.056	-0.137	-0.155	-0.211	-0.161	-0.136
EPISODIC MEMORY	PreIFR_WordsWordsRecalled	0.147	0.150	0.080	0.168	-0.051	0.057
	PostIFR_WordsWordsRecalled	-0.058	0.037	-0.023	0.085	0.030	0.076
	PreIFR_PicturesWordsRecalled	-0.058	-0.030	-0.073	-0.070	-0.042	-0.062
	PostIFR_PicturesWordsRecalled	-0.097	0.019	0.012	0.037	0.124	0.030
	PrePairedAssociatesWordsRecalled	-0.059	-0.091	-0.038	-0.002	0.012	0.110
	PostPairedAssociatesWordsRecalled	-0.019	0.060	0.049	0.108	0.090	0.081
	PrePairedAssociatesDelayWordsRecalled	-0.055	-0.083	-0.013	0.007	0.044	0.115

	PostPairedAssociatesDelayWordsRecalled	0.070	0.055	0.100	0.122	0.070	0.117

DISCUSSION

The purpose of this study was to evaluate the biomarker signatures of stress and resilience and their relationships with performance over the course of a 12-week nutrition and exercise intervention in a healthy AF population. Our findings indicate that these interventions had mixed effects on the chosen biomarkers despite clear significant increases in physical performance and some increases in cognitive performance. Our results also show that specific biomarkers were associated with certain aspects of these performance measures. Though our population consisted of healthy, active duty AF members, they exhibited a wide range of physiological differences. This suggests that the benefits of exercise and nutrition interventions may be more effective when tailored to the individual subject's physiology.

Aim 1a. – Exercise Intervention

The Exercise Intervention influenced changes in two of the biomarker measures. The exercise intervention significantly reduced subjects' resting NPY levels and reduced subjects' peak cortisol levels and their cortisol response to stress (Table 7). No other biomarkers were affected.

One of the two significant biomarker changes resulting from the 12-week exercise intervention was decreased low stress (baseline) NPY levels (Table 7). However, the Bonferroni multiple comparison procedure showed that the significance difference occurred within the training intervention; the pre-to-post levels (Week 1 to Week 14) were not significantly different (Table 9). This suggests that the intervention did not

confer lasting change. While not statistically significant, we also observed a trend that high stress levels of NPY and the change from low to high stress levels of NPY both increased with exercise training (p=.080, p=.060, respectively) (Table 7). Though NPY is considered a marker of stress resilience, it is important to consider the conditions under which it is measured. Higher levels of NPY released *under stress* confer performance benefit (Lieberman, 2016; Morgan, 2000; Morgan 2002). Baseline levels, however, are not well understood. *High* resting levels are associated with insulin resistance, obesity (Kuo et al. 2007), and atherosclerosis (Li et al. 2003), but *lowered* resting levels are associated with trauma exposure (Morgan, 2003). It is therefore unclear what role baseline NPY levels play. Our correlation analysis shows no association between low stress NPY levels and physical or cognitive performance, but high stress NPY levels are positively associated with better agility, core endurance, and muscle endurance scores, as well as lower body fat percentage. This evidence suggests that stress-induced NPY release is a more accurate biomarker of performance than resting NPY measures.

The second significant biomarker change resulting from the 12-week exercise intervention was a reduced cortisol response to the VO_2 Max challenge (Table 7). This was not unexpected, as studies have shown reduced cortisol response to stress after exercise training interventions (Kraemer, 1999). Rimmele, et al. 2007 showed trained vs. untrained subjects have a reduced cortisol response to a psychosocial stressor. Subjects' reduced cortisol response to stress may also be due to a conditioning response. Our lengthy pre-testing battery of measurements, blood draws, tests, and surveys is a multi-faceted stressor in itself. By post-testing, subjects are familiar with the lab environment,

the tests, and the experimenters, thus we would expect to see a decrease in their cortisol response as a result of repeat exposure.

Aim 1b. – Nutritional Intervention

The Nutritional Intervention yielded one significant biomarker change: decreased high stress NE levels (Table 8). These changes were only observed in the High Nutrient group, while the Low Nutrient Group levels increased, suggesting that the experimental supplement affected the NE stress response (Figure 3). These findings support the data from Hamazaki, 2000, who found that DHA supplementation reduced plasma NE levels in students during a 2 month final exam period. However, the type of stress the subjects experienced was different. Additional research will be needed to confirm that DHA reduces peak NE levels caused by an acute physical stressor.

As noted, we observed changes in some, but not all biomarker signatures over the course of the interventions. For example, subjects' cortisol response was attenuated post-intervention, but their low stress (baseline) cortisol levels did not significantly change. Past research shows mixed results regarding changes in cortisol levels after exercise intervention. While Kraemer et al. 1999 found decreased levels in healthy adult resting cortisol post 10 week exercise intervention, this change was only significant in the older subset of participants. Our findings suggest that exercise interventions have a greater effect on the release of cortisol in response to acute stress compared to resting levels. Other biomarker levels, such as serotonin, were not affected by either intervention. This study is the first to examine changes in peripheral serotonin resulting from supplementation and exercise.

Another explanation for the limited biomarker changes could be a benefit plateau effect. Our population is markedly different from the general population. Active Duty AF members are on average healthier than the general population – they are required to pass a physical fitness test each year, they have lower rates of obesity, and they have guaranteed access to medical care, including preventative care (Eilerman et al., 2014). They also exhibit lower stress biomarker levels and higher resilience biomarker levels (Shia et al., 2015). Though our study population was only slightly more fit than that of the AF population overall – 17.7% of our subjects had >30.0 Body Mass Index score compared to 18.9% of the AF at large (Eilerman et al., 2014), our population was also highly motivated. They not only volunteered themselves for a 14-week intervention with daily involvement, but by removing any subjects that had <80% participation, we naturally selected the most motivated within that subgroup. Because our population was already healthy, highly motivated, and have more ideal biomarker signatures, they may require a longer or more intense (Yerkes-Dodson, 1908) intervention period before wide-ranging changes in stress and resilience markers occur. The benefits of diet and exercise may have diminishing returns.

Aim 2. - Biomarker-Performance Associations

We sought to assess the relationships between biomarkers of stress and resilience and physical and cognitive performance measures. The Pearson correlation analysis illuminated several points.

First, we found that biomarker levels released under high stress conditions were more tightly correlated with physical performance than those under low stress conditions

(Tables 10-25). This was not unexpected, as the performance measures are themselves high stress conditions. The only exception to this was serotonin – low stress levels were more correlated to performance than high stress levels, though not strongly (Table 28). Serotonin functions in part to regulate peripheral vascular tone (Rapport, 1948) and in control of breathing during exercise (Bach, 1993) which may explain the correlations we see with anaerobic performance, that is, increased serotonin availability may better regulate blood pressure and increase the drive to breathe during exercise. These correlations also mark serotonin as a potential predictor of physical performance. This is critical for application, as biomarkers are more useful if their *resting* levels are indicative of future performance.

Second, certain biomarkers were associated with specific aspects of performance. For example, we observed positive relationships between high stress NPY and agility, muscle endurance, core endurance, and aerobic power scores (Table 23). Peripheral NPY is secreted upon SNS activation and acts as a blood pressure regulator. Exercise increases skeletal muscle blood flow by way of arterial dilation, and NPY acts as a vasoconstrictor to balance this effect in order to maintain adequate arterial pressure and flow (Holwerda, 2015). This mechanism may explain why NPY levels positively correlate with physical performance. The more NPY secreted during exercise may better regulate and maintain blood pressure and flow during the task, aiding in physical performance.

Third, though strong relationships were seen between biomarkers and physical performance, their relationships with cognitive performance were weaker (Tables 30-39). This was not unexpected, as all biomarkers were measured peripherally and only cortisol

and unsulfated-DHEA easily cross the BBB to exert central effects. Despite weaker relationships, some patterns emerged. Cortisol and DHEA-S had more correlations with cognitive performance than the other biomarkers, and these correlations tended to be negative with respect to cortisol and positive with respect to DHEA-S. This pattern can be seen in the Working Memory and Episodic Memory tasks (Table 31 and Table 33). This supports existing data from Vaz, 2011 which showed that increased cortisol levels are connected with poorer working memory. Similarly, Alhaj, 2006, showed that DHEA levels are associated with better episodic memory, though they did not also measure DHEA-S levels.

Not all biomarker-performance relationships were maintained after the interventions. Pre-testing cortisol response was positively associated with muscle endurance, agility, aerobic power, anaerobic power, and balance, but post-testing cortisol response was not (Table 12, Table 13). This pattern was also observed in NE for muscle endurance, agility, aerobic power, and anaerobic power (Table 19, Table 20). If the levels of stress biomarkers were simply elevated during pre-testing due to the stress of unfamiliarity, we would not expect the levels to then be correlated with performance measures. This suggests that untrained individuals may gain performance benefit from higher cortisol and NE responses, while trained individuals do not. This is supported by the data from Rimmele, 2007 and Bloom, 1976. Elevated release of cortisol and NE under stress may be a compensatory mechanism for lack of physical fitness.

While we found associations between biomarkers and performance, it is important to not overlook simpler measures that may have correlations of equal or greater strength.

Lean Muscle Mass (LMM), for example, was more tightly correlated with our physical performance measures than any of the five chosen biomarkers. This may call into question the utility of these biomarkers. Though LMM is a better predictor of the straightforward performance criteria measured in this study (push-ups, sit-ups, pull-ups, etc.) it may be less effective when predicting more complex performance tasks like underwater navigation (Morgan, 2009) or mock captivity and interrogation (Morgan, 2002). Additionally, when studying less diverse populations in which subjects have similar body compositions (Special Forces, etc.), biomarkers of stress and resilience may be the key differentiating factors between high and low performers. To apply biomarkers for the assessment of performance, it is necessary first to carefully consider the type and context of the task and the physiology of the participants.

The magnitude of the Pearson correlation coefficient (R) indicates strength of relationship, with the strength increasing further from 0. The R^2 value indicates amount of variance explained in Y by X. For example, the R^2 for high stress cortisol and agility score is $-0.364^2 = .1325$, meaning that 13.25% of the variance in agility scores is explained by cortisol. However, even a strong relationship does not imply cause and effect. Controlling for confounding variables known to affect biomarker levels was performed, but there may be additional unknown factors influencing biomarker levels. For this reason, we must cautiously interpret and apply these results. Rather than directly attributing performance changes to biomarker levels, these correlation data may be more appropriately used to identify which biomarkers to monitor for more complex tasks that combine multiple aspects of physical and cognitive performance, or as a starting point to

further investigate the mechanisms by which these biomarkers may influence performance change.

Clinical Relevance

Though statistically significant, the observed biomarker changes may not be clinically relevant for our population. The pre- and post-testing baseline values for both NPY and DHEA-S, for example, were within normal ranges (Khatun, 2000; Salek, 2002). Active Duty Airmen generally exhibit lower stress biomarker levels and higher resilience biomarker levels compared to volunteer firefighters (Shia et al., 2015). Reducing stress biomarker levels already within normal ranges may not confer meaningful health benefit. Likewise, raising levels of resilience markers that are already at the optimal end of the healthy range may not prove beneficial until an individual experiences extreme stress. However, the future applications of these results are intended *also* for deployed populations, elite forces, and other groups that are more likely to face severe, long-term, and/or compounded stress. Therefore, the statistically significant results gained from this study may not become biologically meaningful until they are applied to populations under circumstances of extreme stress.

Limitations

This study has several limitations which should be considered. Due to the logistics of testing our subjects in the limited time allotted, subjects' blood was not drawn at the same time of day. To account for this, the time of day was recorded for each draw

and was factored in as a covariate during statistical analysis for cortisol, which exhibits diurnal fluctuation.

While it has been demonstrated that the chosen biomarkers are associated with stress and performance, there exist other markers that also reflect stress-related outcomes such as IL-1, IL-6, C-reactive protein, β-NGF, and testosterone. Nutritional biomarkers may also be useful for tracking health during supplementation interventions. Current technology only allows for a snapshot of a subject's physiology. Until we have the ability to perform comprehensive, real-time biomarker tracking, additional markers should be monitored to better grasp the changes occurring in participants' physiology. For future research, a large biomarker panel may be more appropriate for assessing biomarker changes over time and their relationships with performance.

Despite fairly stringent exclusion criteria, our population was not as homogenous as anticipated. Even though our population was a healthier subset of the general population, our subjects still exhibited a wide berth of physiological differences. For example, subjects' initial body fat percentages ranged from 12.9% - 48.5%, subjects' initial lean muscle mass weight ranged from 77.4 – 189.6 lbs, and subjects' initial VO_2 Max scores ranged from 24.9 – 79.3 mL/kg/min. Despite these differences, all subjects underwent the same training regimen and were given one of two supplement formulas. Individualization of the interventions may have improved performance and biomarker signatures more effectively. Future studies that target performance may benefit by focusing on the needs of the individual, taking into account age, gender, weight/BMI,

total daily energy expenditure (TDEE), specific dietary needs, and using targeted exercise strategies to enhance areas of weakness or limitation.

Subjects' diets were not controlled in this study. Subjects were expected to self-adjust their caloric intake to account for the additional calories of the supplement, but this was not specifically tracked. To offset these variables, participants were asked to take a once weekly survey (DNI) to assess dietary intake, sleeping habits, alcohol consumption, and nicotine use. Though these data were largely qualitative, they were analyzed by a registered dietician and no significant differences were found between the two groups.

Nutritional supplementation studies, particularly those researching multivitamins, have shown mixed results (Brown, 2017). One general consensus in this field is that supplements are effective if the person is deficient in the nutrient being supplemented (Blumberg, et al., 2018). Because our supplement contains ingredients that can be obtained through diet, it is possible that we observed few significant changes in the experimental group due to a lack of initial nutrient deficiency in our participants. Though subjects' general eating habits were evaluated with the DNI survey, quantitative nutritional analysis data was not obtained. We do know that few of our subjects ate fish regularly, but we do not know the levels of omega-3 fatty acids in their blood to determine adequacy or deficiency, for example. Future studies would benefit by adding this analysis in order to more accurately ascribe changes to the nutritional supplement itself and not an unknown outside factor.

Similarly, this study also lacked a nutrient *absorption* analysis. To decipher whether or not changes are occurring due to the nutritional supplement, it is first

important to know that the ingredients in the supplement are being absorbed by the body and not simply ingested and excreted. Knowing the pre and post serum levels of key nutritional markers (in our case, lutein, DHA, phospholipids, and Ca-HMB) will also allow us parse *which* of these ingredients may be responsible for changes.

Though this study included a placebo group, it did not include a sham group with subjects who took the placebo supplement but did not participate in the exercise intervention or a group with subjects that did not participate in either. As such, we cannot rule out any effects of time alone on biomarker changes. As mentioned previously, repeat exposure to the testing protocols also may have resulted in a conditioning effect that is responsible or partly responsible for the observed within-group changes.

Lessons Learned - Logistics of Longitudinal Biomarker Studies

Tracking biomarkers over multiple years presents unique logistical challenges. Even stored at or below -20 degrees F, degradation of sample analytes occurs (Dörner & Böhler, 1996; Koch & Platoff, 1990; Zhang et al., 1998). To minimize this effect, each cohort's blood samples were tested after the completion of their respective intervention cycle. However, this produced another logistical challenge. Assay kits ordered more than a few months apart may not be of the same lot production, and therefore may introduce significant variability among the cohorts. Our dataset initially showed this type of variability. To mitigate this, representative samples from multiple cohorts were assayed on the same plate to check for consistency. Cohorts with representative samples significantly different from the original assay results were rerun entirely. For future studies, a potential solutions for these issues are as follows:

1) Depending on the stability of the analytes, all samples may be assayed at the conclusion of the study and therefore all within the same assay lot, and a correction factor(s) may be applied to account for each analyte's rate of degradation. This method assumes samples do not degrade entirely and that rates of decay are well-established.
2) Samples may be analyzed after each cohort as was done here, but with the added cooperation of assay production companies to reserve enough kits within the same lot to cover the estimated final sample count. This method is costly (more kits must be purchased to cover the higher end of the final subject count estimate) and depending on the length of the study, the kits may expire prior to completion.

CONCLUSIONS

This is one of the first studies to examine the role of an innovative nutritional supplement with mandatory exercise training for the enhancement of physical and cognitive function in active duty AF personnel. More specifically, we were able to test for the first time in humans whether this intervention strategy moderates stress and resilience biomarker levels with respect to cognitive and physical performance. Active duty military, especially those deployed, face increased levels of stress that put them at risk for impaired performance (Booth-Kewley 2010). It is therefore imperative that the AF to develop non-invasive strategies to enhance airmen resilience and optimize readiness. This study presented evidence that this nutrition and exercise intervention can reduce the cortisol stress response and decrease peak stress cortisol and NE levels. These changes, however, were modest and may not be clinically relevant. This study also showed presented evidence that suggests stress-induced biomarker release is generally a more accurate predictor of physical performance than resting measures, and that many of these biomarker measures are correlated with specific aspects of physical and cognitive performance.

For future research, we recommend that these diet and exercise strategies be tailored to the individual's needs for greater efficacy. To more accurately assess changes occurring due to these strategies, we recommend that additional control and sham groups be included, that nutrient absorption analysis of supplements be performed, that

additional biomarkers of stress, resilience, and inflammation be measured, and that care is taken to analyze these markers under the appropriate conditions.

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APPENDIX

Demographic & Medical Screening Questionnaire

NOTE: Please complete this form accurately and honestly. This is in your best interest, as it will help reduce injury risk exposure that is associated with your participation in this study.

Subject ID_____ Age_____ Date_____

Handedness:_____

Highest education level completed: _____

Estimated GPA at highest education level: _____

If you are currently attending school, please indicate your current status:_____

_____

If you attended college, what was your major: _____

Years of military service: _____

Current military rank: _____

Current military career field: _____

Are you currently on a medical or pregnancy profile? YES/NO

Are you currently taking a multivitamin? YES/NO
If so, please list and/or describe:
_____
_____
_____
_____
_____

Are you currently taking alertness altering medications? YES/NO
If so, please list and/or describe:
_____
_____
_____
_____
_____

Are you currently taking antibiotics or blood thinners such as aspirin? YES/NO
If so, please list and/or describe:
_____

Are you currently taking nutritional supplements for physical fitness? YES/NO
If so, please list and/or describe:

Do you smoke regularly? YES/NO
If yes, how often:

Do you regularly drink alcohol? YES/NO
If yes, how often:

Do you experience fainting spells? YES/NO
If yes, how often:

Do you have a family history of early cardiac death? YES/NO
If yes, please describe:

Have you recently been diagnosed with high/low blood pressure, a cardiac illness, or high cholesterol? YES/NO

If yes, please describe when:

_____
_____
_____
_____
_____

Do you have a history of asthma or other respiratory problems? YES/NO

If yes, how often:

_____
_____
_____
_____
_____

Have you experienced black-outs or bouts of dizziness during high physical exertion? YES/NO

If yes, how often:

_____
_____
_____
_____
_____

Do you currently experience, and/or are you being treated by a medical provider (e.g., MD, physical therapist, chiropractor etc.), for any of the following: Infection, anemia, diabetes, allergic reaction to adhesives/tape, Urticaria (hives), atopy, swelling, musculoskeletal pain/injury (including back or joint pain), sleep disturbances, stroke or TIA (temporary stroke)

If yes, please explain:

_____
_____
_____
_____
_____

Have you ever experienced any other serious medical illness or injury other than those mentioned in the previous questions?

If yes, please explain:

_____
_____
_____
_____
_____

Have you experienced, or are you currently experiencing, any medical symptoms or complaints (e.g., back pain, joint pain, headaches, persistent nausea, etc.) that have not been evaluated by a medical provider?

If yes, please explain:

_____
_____
_____
_____
_____

Are you recovering from a recent surgery in the past 2 years? YES/NO

If yes, please explain:

_____
_____
_____
_____
_____

Do you exercise? Yes/No

What activity/activities? _____

How long have you been exercising? _____

How many days per week do you exercise? _____

How many minutes per day? _____

What kind of shoes do you wear when working out? _____

Have you ever worn physiological monitor (Polar heart rate monitor) while exercising?_____

Do you count your pulse during your workout? _____

What is a typical 24 hour for yourself?

_____ Work
_____ Relaxation
_____ Eating
_____ Sleep
_____ TV
_____ Driving/Riding
_____ Exercise

CLEARED/NOT CLEARED FOR RESEARCH PARTICIPATION

_____

MEDICAL OBSERVER SIGNATURE/DATE

Life Stress Questionnaire

Subject ID								
Date								

IN **THE LAST 12 MONTHS:** Listed below are a number of events which sometimes bring about change in the lives of those who experience them. Please CHECK either YES or **NO** to indicate whether **YOU,** or if indicated, your mate, spouse, close friend or family member have experienced the event in the past 12 months. FOR THE EVENTS YOU CHECK "YES", please indicate whether you viewed the event as having either a **BAD or Good** impact on **YOUR** life at the time the event occurred, regardless of what may have eventually happened as a result of the event. Whether the event happened to you or someone important in your life, please indicate whether it had a **BAD or Good** impact on **YOUR** Life when it happened. Also for the events you circled "YES," indicate how stressful the event was at the time the event occurred.

SCHOOL

Have any of these events happened to you in the last 12 months?			When the event happened, was the impact on your life		When the event happened, how stressful was the event			
	YES	NO	GOOD	BAD	VERY	SOMEWHAT	LITTLE	NOT
1. Started or changed school or training program?								
2. Graduated from school or training program?								
3. Had significant added responsibility at school?								
4. Had significant problems in school or training program?								

WORK

Have any of these events happened to you in the last 12 months?			When the event happened, was the impact on your life		When the event happened, how stressful was the event			
	YES	NO	GOOD	BAD	VERY	SOMEWHAT	LITTLE	NOT
5. Started regular work for the first time?								
6. Returned to work after not working for a long time?								
7. Looked for but could not find employment?								
8. Retired?								

9. Changed jobs?								
10. Had trouble with a boss?								
11. Laid off or fired.								
12. Stopped work or quit.								
13. Took on a greatly increased workload?								
LOVE								
Have any of these events happened to you in the last 12 months?			When the event happened, was the impact on your life		When the event happened, how stressful was the event			
	YES	NO	GOOD	BAD	VERY	SOMEWHAT	LITTLE	NOT
14. Separated from mate for more than two weeks due to an argument or discord?								
15. Got a divorce?								
16. Started dating after not dating for a long time?								
17. Trouble with in-laws of mate's parents?								
HEALTH								
Have any of these events happened to you in the last 12 months?			When the event happened, was the impact on your life		When the event happened, how stressful was the event			
	YES	NO	GOOD	BAD	VERY	SOMEWHAT	LITTLE	NOT
19. Hostitalization for a life- threatening physical illness, disability, injury or major surgery?								
20. Hospitalization for a less serious physical illness, injury, or tummor surgery?								
21. Hospitalization for an emotional or psychiatric illness.								
22. Progression of IUV infection (e.g. t-cell decrease, developing symptoms or AIDs								

23. Recovered from any of the above illnesses, disabilities, or injuries?								
24. Change in personal habits (include sleeping, eating, exercising, smoking, drinking or drug use)?								
25. Accident...Motor vehicle?								
26. Mate or spouse had major change in health status?								
27. Close friend or relative had major change in health status?								
LEGAL								
Have any of these events happened to you in the last 12 months?			When the event happened, was the impact on your life		When the event happened, how stressful was the event			
	YES	NO	GOOD	BAD	VERY	SOMEWHAT	LITTLE	NOT
28. Physically assaulted or attached?								
29. Physically/emotionally abused or raped?								
30. Involved in a law suit court case or trouble with the law?								
31. Mate or spouse involved in crime or legal mater?								
32. Close friend or family member involved in crime or legal matter?								
Money and Finance								
Have any of these events happened to you in the last 12 months?			When the event happened, was the impact on your life		When the event happened, how stressful was the event			
	YES	NO	GOOD	BAD	VERY	SOMEWHAT	LITTLE	NOT

33. Took out a large mortgage or a loan of more than one- fourth of family income?								
34. Financial situation worsened (repossession of car, loan foreclosed, property or money lost, gambling losses, loss of income source)?								
35. Went on Welfare or Disability?								
36. Went off or lost Welfare or Disability?								
37. Chronic financial stress?								
FRIENDS AND FAMILY HOUSEHOLD								
Have any of these events happened to you in the last 12 months?			When the event happened, was the impact on your life		When the event happened, how stressful was the event			
	YES	NO	GOOD	BAD	VERY	SOMEWHAT	LITTLE	NOT
38. New person (other than mate) became a resident in the household?								
39. Started to live alone?								
40. Started to live without any children at home?								
41. Someone stayed on in the household after he/she was expected to leave?								
42. Serious family argument other than with mate (e.g. mother, brother, child)?								
43. Serious argument with close friend?								
44. Seeing less of close family member other than mate?								
RESIDENCE								

Have any of these events happened to you in the last 12 months?			When the event happened, was the impact on your life		When the event happened, how stressful was the event			
	YES	NO	GOOD	BAD	VERY	SOMEWHAT	LITTLE	NOT
45. Moved to a better residence or neighborhood?								
46. Moved to a worse residence or neighborhood?								
47. Lost a residence (e.g. home or apartment) through fire, flood, or other disaster, or a major destruction of it?								
DEATH								
Have any of these events happened to you in the last 12 months?			When the event happened, was the impact on your life		When the event happened, how stressful was the event			
	YES	NO	GOOD	BAD	VERY	SOMEWHAT	LITTLE	NOT
48. Spouse/mate died?								
49. Spouse/mate you are separated or divorced from died?								
50. Child died?								
51. Other immediate family member died (mother, father, brother, sister)?								
52. Other close relative (s) died (grandparent, aunt, uncle, in-laws. etc.)?								
53. Close friend died?								
NEW LIFE								
Have any of these events happened to you in the last 12 months?			When the event happened, was the impact on your life		When the event happened, how stressful was the event			
	YES	NO	GOOD	BAD	VERY	SOMEWHAT	LITTLE	NOT
55. Birth of grandchild or great grandchild?								
56. Self or close family member became pregnant?								
57. Birth or adoption of first child?								

58. Birth or adoption of second or later child?								
59. Birth of grandchild or great grandchild?								
60. Found out that you could not have children?								
61. Close friend or relative had childbirth related change?								
OTHER								
OTHER RECENT EXPERIENCES WHICH HAVE HAD AN IMPACT ON YOUR LIFE (write in)			When the event happened, was the impact on your life		When the event happened, how stressful was the event			
	YES	NO	GOOD	BAD	VERY	SOMEWHAT	LITTLE	NOT
62								
63								

Brief Resilience Scale

Please indicate the extent to which you agree with each of the following statements by using the following scale:

1= Strongly disagree, 2= Disagree, 3=Neutral, 4=Agree, 5= Strongly agree

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I tend to bounce back quickly after hard times	1	2	3	4	5
I have a hard time making it through stressful events	1	2	3	4	5
It does not take me long to recover when something bad happens	1	2	3	4	5
It is hard for me to snap back when something bad happens	1	2	3	4	5
I usually come through difficult times with little trouble	1	2	3	4	5
I tend to take a long time to get over set-backs in my life	1	2	3	4	5

Scoring: The BRS is scored by finding reverse coding items 2, 4, and 6 and finding the mean of the six items.

Daily Nutritional Intake Questionnaire

Date:											
Subject #:											
Avg hours sleep per night in the last week:											
Describe what you ate yesterday in the best detail you can:											
	What foods?	**Approx. how much? (Use units like cup, ounces, fist, etc)**			**What drinks?**			**Approx. how much? (Use units like fluid ounces, cup, bottle, etc)**			**What time?**
Breakfast											
Lunch											
Dinner											
Snacks											
Supplements/Vitamins	**Which?**	**How much per day?**									

Caffeine	**How much per day?**								
Nicotine	**How much per day?**								

Daily Nutritional Intake Questionnaire (Part 2)

Over the past week (**WEEK** days only), at what time did you most often take the supplement? (choose one)

a. 1 Prior to and 1 after the workout
b. 2 Prior to the workout
c. 2 After the workout
d. Other (please list and explain in the box below)

2. Over the past week, (**WEEKEND/HOLIDAY** days only), at what time did you most often take the supplement? (please list and explain in the box below)

3. Which nutritional supplement do you think that you are taking?
    a. High nutrient
    b. Low nutrient

In the box below, please explain why you think this way: